Active RFID and its Big Future

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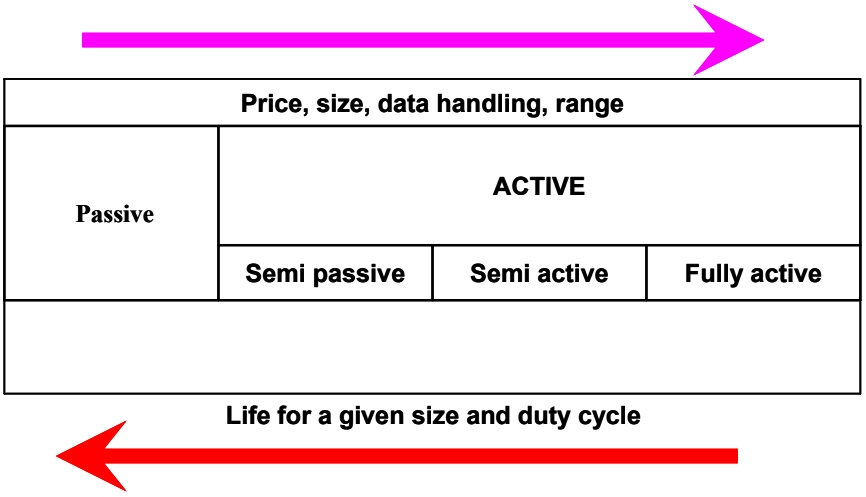
Executive Summary and Conclusions

This report concerns "active" RFID systems meaning those where there is a power source in the tag. The value of sales of systems with these tags will grow by about 3.5 times to reach about $1.4 billion dollars globally in 2014. Today the power source is almost invariably a battery but miniature fuel cells are being trialled and there are other possibilities for the future.

Sub categories

RFID tags subdivide into the categories shown in figure 1. So-called "semi-passive" RFID tags have relatively weak, small batteries because they are not used to increase the range of the tag. "Semi-active" and "fully active" tags boost range and therefore need larger, more expensive, stronger batteries. Fully active tags are rarely used because they are the ones that are on all the time and this is very demanding of the batteries. Semi-active tags are on only when programmed to send a signal, say at given intervals or in response to some event. All active tags of the above three types can be configured to manage sensors in the tag measuring, recording and, if necessary processing a wide variety of parameters. Tags that have sensors are a growth area of active RFID.

Figure 1 Passive RFID compared with the various types of active RFID



Source: IDTechEx

Table 1 Comparison of some of the typical features of passive vs active RFID

FEATURE	PASSIVE	ACTIVE
Size and weight	Small (or thin)	Large
Cost	5 cents to $1	$4 to $100
Life	Virtually unlimited	3 to 7 years
Range	Up to 1 meter (30 meters in ideal conditions)	Up to 30 meters (a few km in ideal conditions)
Reliability	Excellent	Good
Sensor input	Little or none	Any
Can emit continuous signal	No	Yes
Area monitoring/geofencing	Rarely	Yes
Multi-tag reading	Fair or none	Excellent (e.g. thousands)
Location using a beam	Yes, but only short distance	Yes, at long distance
High speed reading	Fair	Excellent
Data retention	Small to medium (e.g. 1Kbit)	Medium to high (e.g. 1Mbit)
Adjustment of signalling to avoid interference with other devices	No	Yes
Combined short and long range link for spot level locating	No	Yes
Very low signal power	No	Yes – no need to get the signal there and back because semi-active and fully active tags emit their own signal and the battery boosts it.
Security features of signal and processing	Limited	Excellent
Event signalling	No	Yes
Electronic manifest	No	Yes
Data logging	Primitive or non-existent	Yes

Source: IDTechEx

Great variety

Today, millions of semi-passive RFID tags are used yearly for applications such as monitoring blood or food in transit. However, the biggest success of active RFID is the car "clicker" where 45 million are used yearly and about 400 million have been delivered since launch in 1993. Significantly, this is a market from nowhere as it does not replace anything and we expect other such new applications to boost the active RFID market in the years to come.

Project cost, size and payback

The largest orders for active RFID systems are for complete systems and system integration. Active tag projects typically involve expenditure of tens of thousands of dollars to tens of millions of dollars, the largest ones being military in nature. For example, Savi Technology carried out a project for the US Military six years ago for $111 million and the company has subsequently landed active RFID systems orders from the US Military for tens of millions of dollars at a time. Orders for car clickers and their interrogators sold together can involve millions of dollars. There is reason to believe that larger RFID projects will be forthcoming in future.

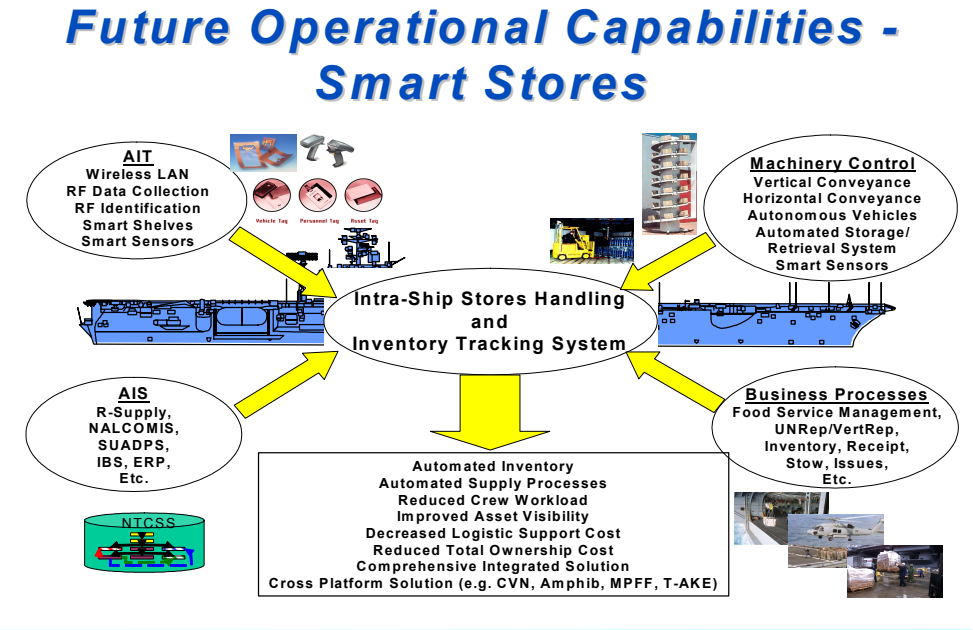
As with passive RFID, paybacks normally lie in the range of one to two years but, as with passive RFID, many projects involve security applications where a payback cannot be calculated. Actual examples of project costs and paybacks are given in the case studies active RFID analysed in chapter 2.

Military, Logistics and Automotive/ transportation are dominant applications so far

The largest spend on active RFID systems with tags has been about $1 billion cumulatively on car remote locking systems followed by $600 million in military applications of which about $100 million has been spent on the tags and interrogators and much of the rest on integration with legacy systems. The largest number of active tags sold has been in Automotive/Transportation – notably car remote locking devices.

The ongoing importance of Military applications is illustrated by the plans of the US Navy shown in figure 2.

Figure 2 US Navy program for the ship of the future based on RFID and allied technologies



Source: US Navy

Analysis of 75 case studies

In our analysis of 75 active RFID case studies from 18 countries, the largest number of projects we have located has been in Logistics with around double the number for each of the nearest contenders - Air Industry, Automotive/Transportation and Healthcare. However, if we had counted each of thirty car manufacturers selling car clickers with their cars, rather than counting them as one, then Automotive/Transportation would have been in the ascendant. Of course, some projects could be classified under several alternative categories and some sectors are relatively secretive, so these sectors may be under-represented. Nevertheless, we conclude that Logistics and Automotive/Transportation are and will remain particularly important applicational sectors for active RFID for some years to come.

Containers and vehicles are the main items that are tagged

In the case studies, the items that are tagged were mainly containers, followed by vehicles, conveyances and people and this probably reflects the market as a whole. Car clickers are products in their own right of course and do not tag anything. Tagging of people is nonetheless a significant and growing sector.

Frequencies are varied

The choice of frequencies narrows towards the higher frequencies as longer ranges are demanded, partly because of radiation laws. However, in many applications different frequencies are used to do exactly the same job, the choice apparently relating more to the suppliers' preference than any proven economic or functional case. However, 433 MHz is the most popular

frequency for active RFID at present, mainly driven by the preferences with car clickers and military applications.

Ranges are varied

Most of the case studies refer to ranges of up to five meters, closely followed by 5 to 30 meters but about 20% are in the range 30 to 300 meters. Although a few companies have claimed to achieve up to a few kilometres range over the years, we have yet to find any such systems in action. There are many reasons for the choices of range for active tags, including the fact that semi-passive tags cannot achieve the longer ranges. Short range avoids confusion between small things, medium range copes with vehicles and people etc passing through large constricted areas and long range is needed to locate things at a distance using beams. Positioning using techniques such as triangulation is not common in RFID as yet but geofencing (monitoring movement between areas by having interrogators at entry and exit points, as an example), is commonplace.

New forms of battery – Smart Active Labels

Standard batteries available in shops are the most common form in active RFID so far. Of these, button batteries, otherwise known as coin batteries, are the most popular followed by standard cylindrical batteries. Most are fitted so they can be replaced and the most common replacement time is 3-7 years. A minority of batteries are sealed into the RFID tag permanently and the whole tag is then disposed of in 3-7 years in the main. With the advent of cheap, thin batteries from several companies (soon to be ten) we are seeing RFID Smart Active Labels (SALs) being created that are thin and flexible enough to go in locations previously denied to active RFID and cheap enough to be disposable.

The most important countries

In our sample, by far the largest number of active RFID projects are in the USA. The UK comes next followed by a wide variety of other countries well behind.

Standards

There are several applicational standards for active RFID, whether fully active, semi-active or semi-passive but the standards situation is far more primitive than with passive RFID because passive RFID is now moving strongly into "open" applications where many service providers may read the tag and even write data onto it provided they obey the rules. By contrast, almost no applications of active tags are open though that may change in future as very low cost versions are developed.

Reflecting the growing importance of 433 MHz as a carrier frequency for active RFID a proposal has been submitted for a simultaneous new work and item committee draft on the parameter for air interface communications as "part 7" of the ISO 18000 series for RFID item management. ISO 18000 is the only data transfer standard in the overarching ISO series of global standards on RFID.

ISO 18000 is subsuming the proposed Electronic Product Code EPC standards for tagging very large numbers of items with unique identity. Active tags will have a part to play in this "tag everything" scenario. It is called The Internet of Things because it envisages the operation of RFID and its communication with other systems "Thing to Thing" (T2T) as being primarily over the internet to save cost.

Privacy issues

Recently, a small number of privacy advocates have been very voluble about what they perceive as the threat to personal privacy from RFID. Many of them spread extreme forms of misinformation on the matter and even those with a more measured view usually advocate strong government regulation and the banning of certain practices such as the tagging of humans. So far, their target has been primarily passive tagging applications, notably tagging everything in shops, partly because these are the large or potentially largest applications involving humans. In fact, the scope for malign invasion of privacy with passive tags is negligible because of their short range and minimal data content. Indeed, those sold in highest volume are read only and contain only an identification number that is incomprehensible to third parties.

Active tags should be more of a concern because they are usually longer range and often read write, containing considerable data beyond simple identification numbers. Nonetheless, it is highly unlikely that any third party could make sense of this information and there is no recording of sensitive personal details. Compared with say video cameras or eavesdropping on cellphone messages, the "threat" from even active tags is very small indeed. In years past, those developing barcodes, smart cards, cellphones and video cameras did not debase their products to meet extreme objections from privacy objectors and the public hugely valued the benefits of such products and massive markets were created as a result.

If there is anything to worry about with RFID it is that EPCglobal has been making, or considering making, concessions to privacy advocates that degrade their products and greatly limit the potential benefits to society. For example, it has proposed banning use of its Electronic Product Code EPC system for tags used on humans, yet such tags perform such invaluable tasks as automating school evacuation in case of fire, preventing the wrong blood being given to people in hospitals and locating children abducted by paedophiles in theme parks. EPCglobal has proposed making all tags killable at the shop checkout yet 30% of the paybacks in retailing come after the checkout including improved product recalls to save life.

We recommend that proponents of active RFID should do more to promote the benefits to society at large and take great care to avoid putting any easily accessible sensitive data on the tags. National legislation concerning data privacy should be taken seriously of course but the bottom line is that alleged privacy issues should not be the major concern of the industry – timely rollout of systems that prevent errors, save life, reduce costs and otherwise benefit society is far more important.

New markets – hand-held homing devices

We noted that the biggest existing application of RFID – car clickers - does not involve anything being replaced, so may it be with the next major breakthrough. A possible candidate for this may be the location of people and assets using single beams rather than triangulation because of the lower cost and simpler infrastructure. That would open up consumer markets for hand held interrogators to find lost children, track pets and so on that carry a small, cheap active RFID tag as well as ubiquitous interrogators in healthcare, industry etc to home in on specific items, even for the police to chase thieves by homing in on stolen goods.

Remote access fobs for other vehicles.

Car clickers will appear on many other types of vehicle, helping to grow this market but although this number will therefore grow steadily, the largest number and value of active RFID tags sold in 2014 will probably be RFID Smart Active Labels SALs not clickers.

New markets – Smart Active Labels

It is too early to be sure of the nature, let alone the timing of new applications for Smart Active Labels and new variants of them. Candidates include monitoring supply chains at distances unattainable with passive RFID and the self adjusting use by and sell by date that consist of an active RFID smart label with a display that indicates a different sell by or use by date as it detects heating, humidity etc. After counting down in response to circumstances, this may display the word "Expired". The whole device will have to be cheap enough to be disposable. Infratab and KSW Microtec have recently launched RFID SALs that record time and temperature and cost several dollars each but price will have to come down to 20 cents or less for billion plus yearly sales in our opinion.

Forecasts for tags

Our forecast for the global RFID active tag market (including semi-active and semi-passive), most of which will be in automotive/ transportation/ logistics/ healthcare/ military, is shown in table 2.

Table 2 Forecasts for the number, unit price and value of the global market for vehicle clickers (remote locking), Smart Active Label SAL RFID and other types of active RFID tag from 2004-2014 in millions of units and millions of dollars.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vehicle clickers number	45	47	50	52	54	55	56	57	58	59	60
Price	2	2	2	1.9	1.8	1.7	1.6	1.5	1.5	1.5	1.5
Value	90	94	100	99	97	94	90	86	87	89	90
SAL number	5	10	20	50	100	150	250	350	400	900	1500
Price	2	2	1.8	1.5	1.4	1.3	1.2	1.0	0.9	0.3	0.2
Value	10	20	36	75	140	195	300	350	360	270	300
Other tags number	2.5	3.0	5.0	6.0	7.0	8.0	9.0	10	13	16	20
Price	20	19	18	16	14	13	12	11	10	10	10
Value	50	5.7	90	96	98	104	108	110	130	160	200
Grand total number	52.5	60.0	75.0	108	161	213	315	417	471	960	1580
Grand total value	150	119.7	226	270	335	293	498	546	577	519	590

Source: IDTechEx

The statistics for non-stop road tolling/ parking tags, which form a major part of the Other category above are given in table 3.

Table 3 Statistics for road tolling/ parking RFID tags worldwide in 2004

Population	20
Yearly unit sales	2
Percentage that are active RFID	10
Number of active RFID yearly	0.2

Source: IDTechEx

Forecasts for systems

The spend on active RFID systems – infrastructure, software and systems integration - dwarfs that on tags and will continue to do so. It varies greatly between applications and is forecast in table 4.

Table 4 Forecast for the value of global sales of RFID systems excluding tags, for vehicle clickers, SALs and other applications 2004-2014 in millions of dollars

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vehicle clickers	95	96	97	99	101	106	114	119	120	124	130
SAL	10	15	20	25	30	40	53	65	75	85	100
Other*	150	160	170	180	190	200	240	300	400	550	620
Total	255	271	287	289	321	346	407	484	595	759	850

* mainly military, prisons and healthcare

Source: IDTechEx

Forecast for total systems plus tags

The total spend on active RFID systems plus tags is given in table 5

Table 5 The total global spend on active RFID systems plus tags.

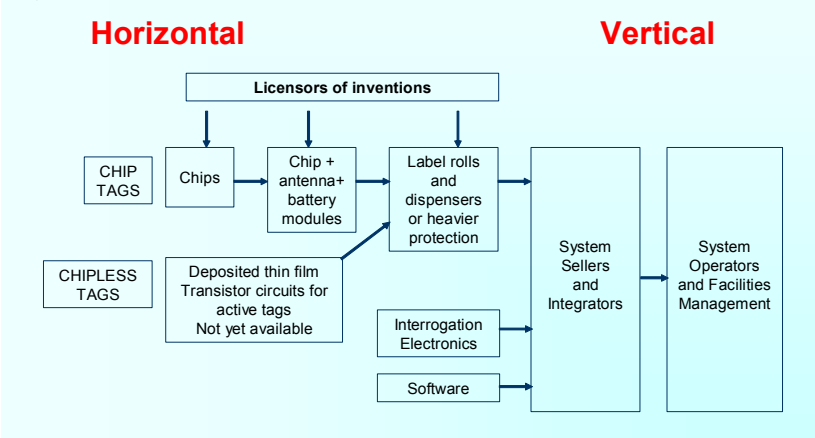
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tags	150	120	226	270	335	293	498	546	577	519	590
Systems	255	271	287	289	321	346	407	484	595	759	850
Total	405	391	513	559	656	639	905	1030	1172	1278	1440

Source: IDTechEx

Value chain

The value chain for active RFID is shown in figure 3. Those at the start of the value chain sell into all applications and those at the end specialize in key vertical markets i.e. specific applicational sectors.

Figure 3 Value chain for active RFID



Source IDTechEx

1. Introduction

1.1. Background

1.1.1. Radio Frequency Identification (RFID)

RFID has its origin in Identification Friend or Foe (IFF) transceivers in aircraft on World War II. That still involves a box of expensive electronics and it is also fitted to most civil airliners today. In this case it combines security with tracking and such multiple business cases are also common in other applications of RFID today. Readers unfamiliar with the acronyms and terminology can refer to the Jargon Buster in Appendix 1 as they read this text.

The list of functions that an RFID tag can perform is rapidly lengthening. Some important examples are given in table 1.1. However, the most recurring benefit is the ability to automate manual or semi manual procedures and replace unreliable automated procedures such as barcode reading with something far more reliable.

Table 1.1 **Important functions that an RFID tag can perform**

FUNCTION	EXAMPLE	
Tracking	Following work in factories with update of status on tag	Active or passive RFID
Tracing	Locating vital equipment in hospitals	Active RFID
Anti-counterfeiting	Designer goods, banknotes.	Passive RFID
Amusement	Some theme parks issue pendants to visitors which combine RFID and other technologies such as Bluetooth to locate lost children, do virtual queuing etc. Thousands of children are abducted in the West every year	Active RFID
Safety	Automated error prevention in hospitals e.g. mother-baby matching, blood-patient matching. There are 25,000 mother baby mismatches yearly in US hospitals.	Passive or active RFID
Security	Intermodal containers have seal which radios identification number immediately any tampering is attempted. Only 2% of intermodal containers entering the US are inspected and any one can contain a nuclear bomb.	Active RFID
Auto-rejection	Some equipment will automatically reject inappropriate or counterfeit spare parts or refills thanks to an "electronic handshake" with an RFID smart label. Thousands of people die every year due to counterfeits.	Passive RFID
Transactions	A smart label in a moving vehicle windshield permits automatic billing of tolls and sometimes recording of transactions. Most road tolling is carried out manually in the same manner as Julius Caesar did it 2000 years ago. This causes congestion and unnecessary cost.	Passive RFID
Proof of ownership	RFID smart labels in valuable products can provide proof of ownership and evidence in court if the product is stolen.	Passive RFID
Anti-theft	Some RFID smart labels detect if a valuable product has been moved even a few millimeters. Others have readers that "hand over" to each other, tracking a product continuously. Globally, consumer goods shrinkage costs $60 billion yearly. Many irreplaceable works of art are stolen from museums and art galleries.	Passive or active RFID
Monitoring environment	Ammunition boxes monitor unacceptable excursions of temperature or humidity and give real time alert and ID. Well preserved drugs need not be trashed. The US Military has found that it is trashing 90% of drugs unnecessarily because printed expiry dates do not represent reality. Value $900 million in one study.	Active RFID

Source: IDTechEx

RFID devices are frequently called tags because they are usually small. They have at least an identification number that can be electronically read at a distance even when not visible. RFID tags have few problems of orientation and obscuration when compared with barcodes, magnetic stripes, printed and written labels etc, so they can be used for more than the tracking and payment which are the normal uses of these traditional media. Anti-counterfeiting is an example of an additional RFID function. Some RFID tags carry far more data than simply identification and some work at frequencies adjoining radio frequencies so they can be very versatile.

1.1.2. Active vs passive RFID

Active RFID tags contain a power source – usually a battery - and passive ones do not. Some have replaceable batteries and some, called unitised active tags, are of a single construction which is thrown away when the battery runs out typically in three to seven years.

Active RFID is complementary to passive RFID. If we take the equivalent situation with light, the passive (no battery) tag is equivalent to a beam of light, from the interrogator, hitting a distorting mirror (equivalent to the tag) that alters the beam in a way that identifies it. The distorted signal is reflected back to the interrogator.

Contrast the alternative - seeing the interrogatory beam and switching on a torch (battery driven tag) to signal back. The return signal can be much stronger - longer range - and more sophisticated responses are possible. Alternatively, for the same range as a mirror (tag with no battery) it can have a smaller footprint. It can initiate the "conversation" and send longer and more complicated data streams. The battery can be used to manage and store information in a sophisticated fashion.

Multitag reading can be done on a grander scale with an active tag – sometimes thousands of tags can be read while they are in the field of one interrogator. Only exceptionally can a passive tag system manage to read 1000 tags in the field at one time. An example is the Magellan 13.56 MHz protocol. The message can penetrate "noisier" environments with an active tag. This is an alternative to taking the benefit of the battery in longer range when one is using an active tag. Although passive tags can sometimes sense things when the interrogator is interrogating them, a battery driven tag can be made to sense a greater variety of things. Indeed, managing many different types of sensor in one tag is relatively easy - and the tag does not have to wait for the interrogator to switch on before it signals that there is trouble out there.

However, a torch is usually larger and more expensive than a mirror. It will not last as long and there is more to go wrong meaning more failures during use. So it is with passive vs active RFID.

Technology

Let us now express this in slightly more technical terms. When an RFID tag is within the interrogation zone of the reader equipment, sufficient power is extracted from the interrogator to power up the tag and it then responds by transmitting data back to the interrogator. This is "passive RFID" and the reflection is called "backscatter" in this industry. Some tags are "active RFID", because they incorporate a battery for increasing range, collating data, tag-to-tag communication etc., but these are usually much more expensive, typically $3 to $100. Table 1.2 compares some of the benefits and disadvantages of active RFID when compared with passive, though not all apply in a given application.

Table 1.2 **Benefits and disadvantages of active RFID vs passive RFID**

BENEFITS	DISADVANTAGES
Longer range	Larger
Works in electrically noisy environments	More to go wrong – higher failure rate in use
Can transmit and/or process more complex data e.g. encrypted	Shorter life in use
Tag can initiate a message	Shorter shelf life
Smaller footprint for range of one meter or more	Battery may need recharging
Tag can incorporate a wide range of sensors and the chip can collate these data	More expensive
Practicable to choose from a wider range of frequencies	Less covert (tag may be detected initiating a signal)
New operating modes are possible such as a signpost interrogator waking up the tag to make it signal to a distant interrogator. Another example is the tag being programmed to dynamically alter its wake up times and duration in response to sensed circumstances.	Heavier
An active tag can be used to interrogate a passive tag	Narrower temperature range than the best passive tags
Larger memory is manageable	Not compatible with printing processes
Battery can drive other functions such as GPS or a display	Usually not an environmental product for disposal
Interrogator may be able to distinguish between tags without using anticontention algorithms in software e.g. better multitag reading is possible.	More likelihood of electrically interfering with sensitive equipment in e.g. hospitals or airports.
Tags may be able to talk to other tags e.g. to locate lost tagged items by forming an ad hoc network.	Greater privacy issues arise at the longer range that is possible

Source IDTechEx

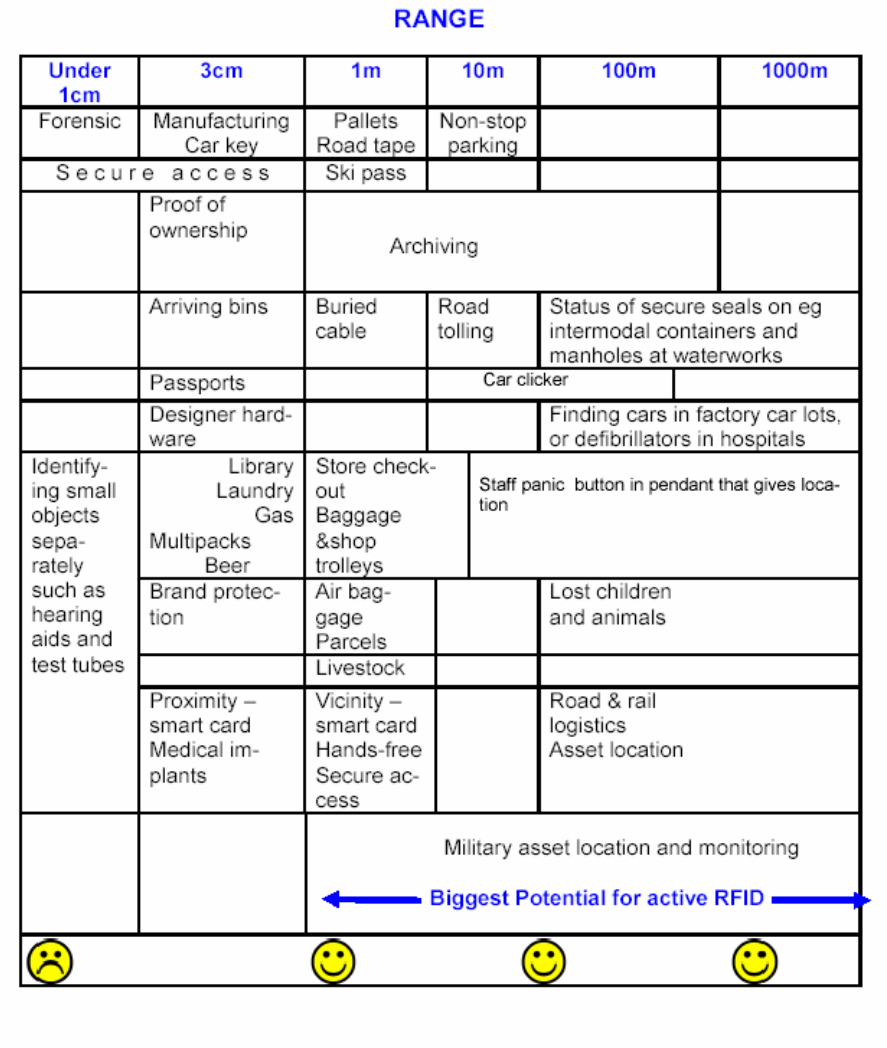
Range of more than the one meter or so of most passive systems is valuable in a significant minority of applications. Indeed, passive tags with a footprint of less than a credit card usually have ranges of tens of centimeters or less. The need is illustrated in table 1.3 and figure 1.1. Figure 1.2 shows an active rag used for theft prevention on a laptop computer.

Table 1.3 **AIM survey of RFID user priorities 2002**

Cost of Tags	35.73%
Cost of Readers	5.87%
Total System Cost	22.13%
ROI	7.20%
Frequency of Operation	6.67%
Read distance	22.40%

Source: AIM

Fig. 1.1 **RFID range required for typical applications**



Source: IDTechEx

Fig. 1.2 **Active tag from Identec for anti-theft. 620,000 laptops were stolen in the USA in 2002.**

Source: Identec

1.1.3. Semi active vs semi passive RFID

Some tags are "semi-active RFID" where the battery is used intermittently to boost range. This may be achieved by setting the tag to wake up only when interrogated or, alternatively to transmit at predetermined intervals or when something has been sensed that it is programmed to signal in real time. Of further sophistication are also possible such as the tag shortening its wakeup intervals or even switching to real time reporting once it has sensed a critical event such as being moved when it should not be.

By contrast, the term "semi passive" is used for active RFID tags where the battery is not used to boost range. It may back up the memory and collate data or encrypt or decrypt messages for example.

Appropriate batteries for either semi active or semi passive intermittent use are now 2 - 100 cents, for the three to seven year's operational life that is usually considered appropriate for most applications. The precise life depends on the duty cycle i.e. how long it is on and how often and at what temperature. Some of these batteries can be recharged by the interrogator's signal, permitting them to be even smaller and cheaper. Costs of batteries of a given capacity are also reducing, though they can never be low enough for active tags to rival passive ones in price i.e. with no battery cost at all.

We summarise the rather confusing nomenclature in table 1.4 In this report, when we refer to active tags we include semi-passive, semi-active and fully active.

Table 1.4 **T he different types of active RFID tag compared with passive tags**

PASSIVE IE NO BATTERY IN TAG	ACTIVE IE BATTERY IN TAG		
	Semi-passive	Semi-active	Fully active
Intermittent or continuous operation	Intermittent operation		Continuous operation
Low cost, small, least breakdowns, longest life.	Does not boost range	Boosts range and therefore demands more powerful battery and tends to need to be operated at higher frequency to achieve range	Boosts range and demands highest battery capacity of all.
Example: label in library book. Checkpoint US	Example: label on blood bags that records time/ temperature profile and gives ID. KSW Microtec Germany Non-stop road tolling tag that keeps record of transactions. SIRIT	Example: Tag the size of a matchbox on an ammunition box (Savi Technology) or tag the size of a videotape for location of new cars in a large car lot (WhereNet)	Tag the size of a videotape on highly sensitive military equipment. Savi Technology.
The most popular form of RFID			The least popular form of RFID
Tags can be made with or without the expense of a silicon chip depending on performance required	Tags employ a silicon chip and an antenna today. In a few years it will be possible to replace the chip with a cheaper, thinner printed transistor circuit but it is, as yet, uncertain whether these can be made to operate at the popular frequencies for active tags of UHF (near 900 MHz), 2.45 GHz.		
Practicable at any radio frequency but most popular at 13.56MHz and around 900 MHz because these passive tags are thin and cheap and have the best range under most power regulations		Practicable at most radio frequencies but most popular at 433 MHz for a combination of reasons discussed in section 1.1.4.	

Source IDTechEx

Figures 1.3 and 1.4 show the new Radianse pendants that track staff and assets in hospitals using semi- active RFID with Global Positioning System GPS.

Fig. 1.3 **Radianse ID-tags: Small, battery-powered and inexpensive**

Source: Radianse

Radianse tags are worn by people and attached to or integrated in medical devices and other assets. The use of RF allows the identification signal to be transmitted even if a hospital gown or a blanket is covering the transmitter. Radio waves can penetrate walls and other opaque materials so a Radianse IPS also uses IR, which provides additional resolution, for example, the side of a wall an asset or patient is located The tags transmit using unique identifiers for each person or asset. Two buttons on the transmitter can be programmed for multiple functions; for example, a button on an asset can be used to notify central supply that it's ready to be returned.

Fig. 1.4 **Radianse Receivers: No specialty cabling, antennas or other infrastructure is required**

Source: Radianse

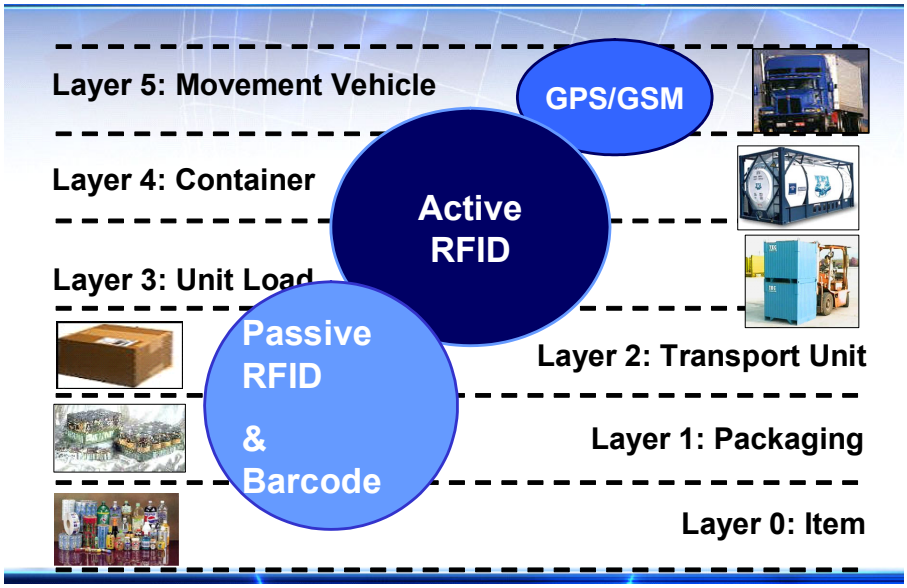
Radianse receivers use standard Ethernet wiring and connect directly to the hospital network where they require miniscule bandwidth. Set IP address with either DHCP or static IP. Each receiver covers up to a 60-foot diameter.

Location data from Radianse tags is collected by internet protocol based Radianse receivers and transmitted over the hospital's existing LAN to Radianse Location Software.

With no special infrastructure requirements, installation is fast, non-disruptive and much less expensive than other indoor positioning solutions.

Active RFID is complementary to both passive RFID and, at the other extreme, positioning systems such as GPS. A view of this from Savi Technology, the company that has landed the largest orders for active RFID systems, is given in figure 1.5.

Fig. 1.5 **Road map of development of active RFID and allied technologies.**



Source: Savi Technology

1.1.4. Many different ideal frequencies for active RFID

As with passive RFID, there will never be a single ideal frequency for all applications because the needs are so varied. Currently the frequencies used vary from 125 KHz to 5.8 GHz and higher frequency systems are just coming on the market, so the choice is actually widening. Later, we deal with these choices in detail.

1.1.5. Smart Active Labels (SAL)

Some proponents offer a very low cost alternative to conventional tags that cost dollars or tens of dollars but in doing so they have to view the choices of frequency rather differently. They may wish to use two cent paper batteries or 20 cent metal ones to achieve 30 to 50 cents per tag. Like Tagcorp with their planned rechargeable battery on a chip, they may even see the basis for a ten cent active tag. However, there is a price to pay. the battery will run out of power more quickly than the batteries used by Savi, TransCore and others in larger, more traditional active tags. The primary concern is then not one of getting round large obstructions. It is not speed of reading. It is conservation of battery power and that may call for other frequencies. If the low cost "smart active label" is in semi passive mode, 13.56 MHz give a convenient low cost construction that operates to smart card standards, for example.

One problem remains. What on earth is a SAL for? Are the proponents correct in optimising it for range and not such things as data handling? Whichever aspect is optimised, what are the applications? Can they be made to last more than a few years and be reliable enough or are the applications constrained to tagging products that are used and discarded within a few years? Are they restricted to situations where the tag is useful, say during a production run and dead soon after the tagged product is purchased and put into use? Today, some Surface Acoustic Wave (SAW) and silicon chip passive tags achieve 10 meters range in crowded environments and 30 meters or more in uncrowded ones, invading the market space previously occupied solely by active tags (semi or fully active). So where, in terms of range, is the "sweet spot" of a SAL and what, if any, applications sit there? Do not expect them to sit in your car windshield, clicker or intermodal container anytime soon, because these items are in use for a very long time and have demanding duty cycles. We suspect that RFID SALs will find many applications beyond today's semi-passive time temperature recording versions, particularly as the shelf life and power capacity of the batteries improves. Some will be the first disposable active RFID tags.

Figure 1.6 shows their concept of a warehouse managed using disposable SALs on packages.

Fig. 1.6 **SAL-C concept of a warehouse managed using disposable SALs on packages. These would be in semi- active mode to achieve range without being too demanding of the thin laminar batteries.**

Source: SAL-C

The Smart Active Labels Consortium (SAL-C), an independent trade association that promotes the concept, has broadened the definition of a SAL to include any low cost laminar device that employs

a battery and chip. That then makes available far bigger markets than those available in RFID, the RFID opportunity being constrained by the primitive performance of the RFID SAL.

1.1.6. Lessons from sixty years of active RFID

From 1944 to 2004 only about 1.5 billion RFID tags were put into use. Of these, about 400 million were active tags but these consisted mainly of one type – car "clickers" which lock or unlock the vehicle at a distance of up to 30 meters. Significantly, the car clicker replaces nothing – the car key is still in use. We can expect this pattern in the future. A large percentage of active RFID tags being sold will replace nothing: they will perform new functions. It will probably also be true that one, or at least only a few. Applications will be responsible for the major proportion of sales. Table 1.5 gives the breakdown of sales of active RFID tags from 1944 to 2004.

Table 1.5 **Sales of active RFID tags from 1944 to 2004.**

APPLICATION	CUMULATIVE SALES OF TAGS MILLIONS	TYPICAL FREQUENCY	PURPOSE
Car clickers	350	433 MHz	Unlocking and locking car at a distance
Bicycles	1		Returning stolen bicycles to rightful owner. Proving theft. Automated storage
Military	0.3	433 MHz	Tracking and tracing sensitive assets such as ammunition boxes and sensing unauthorised movement, humidity, heat etc
Other	50	125-135 KHz, 13.56 MHz, 433 MHz, around 900 MHz, 2.45 GHz and several other frequencies.	Hundreds of different applications, most involving a few tags up to tens of thousands.

Source IDTechEx

Figure 1.7 shows a car clicker

Fig. 1.7 **An active RFID car clicker working in semi-active mode at 433 MHz**

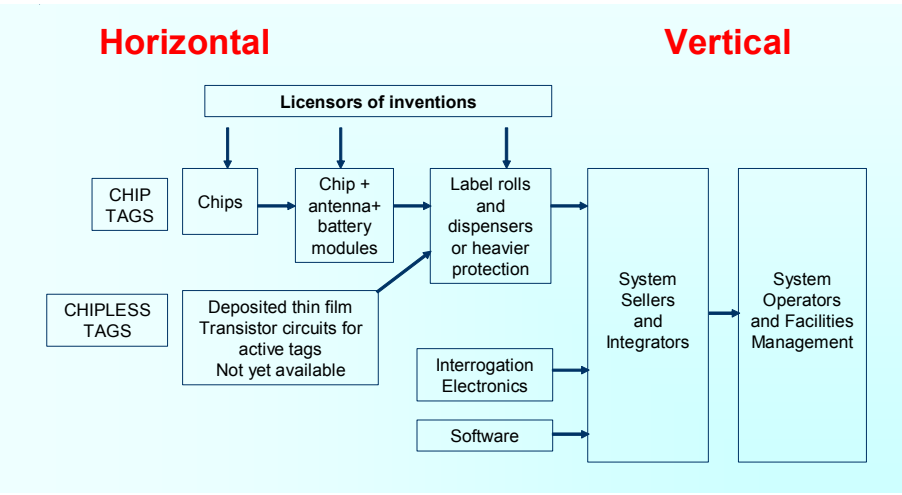
1.2. The active RFID value chain and paybacks

1.2.1. Value chain

The active RFID value chain is shown in figure 1.7. Today, the whole market revolves around tags containing a silicon chip and a battery and antenna but we show

"chipless "construction as well because thin film transistor networks are being developed that will be suitable for active RFID though only at the lower frequencies initially. Some will be printed. The other seven or so chipless RFID tag technologies cannot be battery boosted. In figure 1.7 we show that, at the beginning of the value chain, manufacturers sell horizontally i.e. to anyone for any application. By contrast, at the end of the value chain, those doing system integration etc tend to specialise in given applicational sector i.e. they address "key verticals". This is classical marketing. However, much of the active RFID market involves very small numbers of customised tags and here one meets small suppliers that make tags and readers and do their own system integration. This is a typical feature of an embryonic or small industry.

Fig. 1.8 **Active RFID value chain**



Source IDTechEx

1.2.2. Project costs and paybacks

The largest and the smallest value RFID projects employ passive tags. Active tag projects typically involve expenditure of tens of thousands of dollars to tens of millions of dollars, the largest ones being military in nature. For example, Savi Technology carried out a project for the US Military six years ago for $111 million and the company has subsequently landed active RFID systems orders

from the US Military for tens of millions of dollars at a time. Orders for car clickers and interrogators can involve millions of dollars. There is reason to believe that larger RFID projects will be forthcoming in future.

As with passive RFID, paybacks normally lie in the range of one to two years but it is more common for active RFID to involve security applications where a payback cannot be calculated. Actual examples of project costs and paybacks are given in the sixty case studies active RFID analysed in chapter 2.

The cost structure of active RFID projects is usually different from that of passive RFID projects as shown in table 1.6. A large passive RFID project may involve disposable tags with very large numbers of tags per reader, so tag cost may be the single largest component of cost. That is virtually unheard of with active RFID projects of any size, though this may change somewhat if large numbers of disposable SALs are sold.

Table 1.6 **Cost structure of active vs passive RFID projects**

	ACTIVE		PASSIVE	
	Small project	Large project	Small project	Large project
Tag cost	10%	30%	20%	50%
Other cost*	90%	70%	80%	50%

Source IDTechEx

*Software, infrastructure, installation, commissioning etc

1.3. Total Asset Visibility

Total Asset Visibility (TAV) is a term that implies knowing where assets are at all times. It also implies unique identity for each item and knowing what is happening to it as it happens. Something close to TAV can usefully be applied to inanimate objects, animals and humans. Primarily, TAV is concerned with large numbers of items because it is these that are so poorly controlled today. That includes stationary assets as in museums and archives and moving assets in supply chains.

Of these, the supply chains have the biggest needs because of their massive inefficiency. According to Massachusetts Institute of Technology, MIT, 75 per cent of the cost of the average retail product is the money spent getting it there. Within this, shrinkage is 1-2 per cent of the product cost according to ECR. This is product failing to reach the customer because it expires, is damaged, stolen or misplaced.

Evolution of tracking methods

Over thousands of years, where better knowledge of assets is required, the acquisition of those data has evolved. Word of mouth and manual data entry have given way to barcode scanning and, gradually, this is now being replaced by Radio Frequency Identification RFID tag systems because these are more reliable, accurate and easier to automate. Sometimes they can perform extra functions at no extra cost, such as anti-counterfeiting and storing warranty records. Multiple paybacks are therefore commonplace with RFID.

Later, these RFID tags and other identity and condition-monitoring devices will be embedded in products. We shall even see disposable laminar electronic circuits in packages and products that subsume the RFID function, just as RFID is beginning to subsume the Electronic Article Surveillance EAS (anti theft) function today – one tag does the job of two. Other tracking methods are sometimes combined with RFID or used as an alternative, these including GPS location by satellite and GSM location by cellphone emissions. However, these are too expensive for mass deployment for the foreseeable future, though they are natural allies of active rather than passive RFID because of the possible use of a common battery and similar sizes of tag being involved, that could be combined.

Cost is critical

For most TAV projects the cost of the infrastructure and support services is critical. For the very large projects now being envisaged, the cost of the tags may be the single largest component of cost because so many are involved but the other costs will still be very large. Failure to proceed with a TAV project may be because of inadequate payback being demonstrated in trials but "lack of funds" is also frequently cited even after successful trials and "who pays" can be an issue. This is because the larger schemes are very costly. However, existing infrastructure such as wireless networks is being leveraged to an increasing extent.

Market drivers

Retailers and other end users, seeing benefits of lower costs, increased security etc, are increasingly demanding that their suppliers participate in TAV schemes.

Legal

In, some cases, such as vehicles monitoring that the correct tires are fitted (US TREAD Act - safety) or tracking cattle (public health), new legal requirements make things happen. Although these examples involve passive tags, we can expect examples involving active tags in future.

Cost

One third of the three trillion Consumer Packaged Goods CPG industry involves waste of one sort or another, where RFID can have an impact.

Increased sales – premium pricing

In other cases, major competitive advantage is driving TAV schemes through. This can even include increased sales and premium pricing from better service and new consumer propositions.

Mounting previously impossible campaigns

In the Military, one of the main attractions is to mount operations that would otherwise be impossible and to make normal operations much faster. In the Iraq war, the US Army advanced faster than any Army in history and a congressional report primarily ascribed this to RFID. In fact, this involved active RFID almost exclusively – the subject of this report. Other military forces around the world are now mimicking this capability and it has lessons in the civil arena, such as the speed with which major construction projects can be carried out (see Fluor case study in chapter two for example).

Loose talk about real time

It is common for people to talk of real time tracking of assets using these new technologies. It is true that an asset may be identified and even approximately located at the instant the RFID tag is read provided the electronic interrogator is on line. However, for this to occur more than occasionally, the interrogator must have long range – say tens of meters or even kilometers and/or there must be vast numbers of interrogators that electronically hand over to each other as the asset moves. This is almost never an economic proposition and it is often not feasible technically.

Fortunately, these systems can be applied in layers as paybacks are demonstrated or as a need is identified. A common entry point is "geofencing" where interrogators identity that, "It is in the warehouse", or "It is in the truck", with critical items being more frequently and more accurately located, at extra cost.

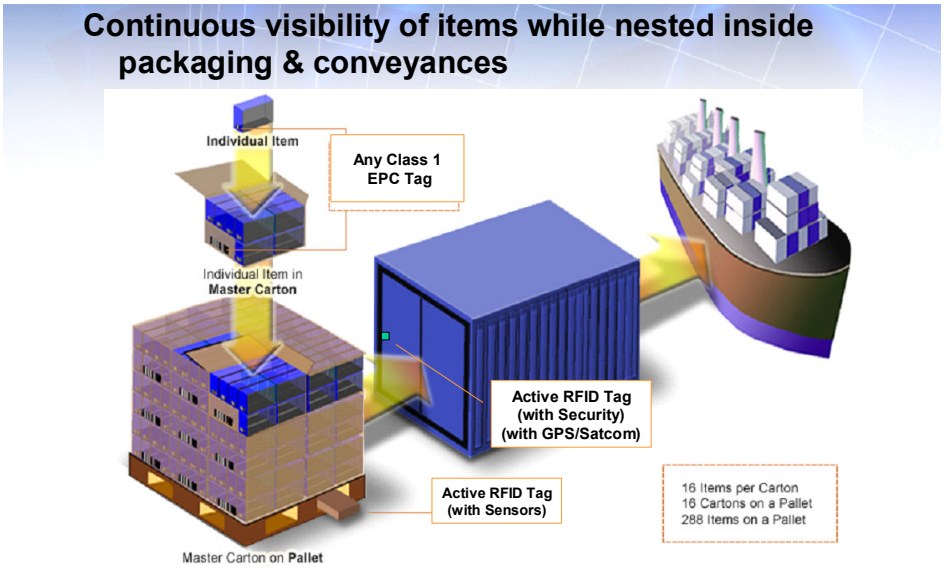
Many input devices

Many input devices are used in TAV. This is because legacy systems are not easily replaced and different forms of device such as barcodes, smart cards and RFID tags are optimal in different situations. Indeed there is no single type of RFID tag that is optimal for most applications because requirements of size, cost, security, speed of reading, data retention and so on are so different. Accordingly, interoperability is a key challenge for many new TAV systems and hot topics include protocols to interface with any data capture device and also multi-frequency, multi-protocol RFID interrogators to cope with a variety of RFID tags.

The US Military TAV program

The largest spend so far on active RFID systems has been that of the US Military despite the largest number of tags sold being for car immobilisers (clickers). We therefore discuss the military activity at some length. The US Military have gone farthest in monitoring certain assets in a TAV program. Spending $600 million so far on the core activity, it has used expensive, sophisticated RFID tags that can be read at tens of meters and, in many cases, be remotely rewritten and sense what is happening to them. Many interrogators are deployed. Figure 1.9 shows a typical deployment.

Fig. 1.9 **Typical military deployment of active RFID tags**



Source Savi Technology

Figure 1.10 gives a military viewpoint of active RFID

Fig. 1.10 **A military viewpoint of active RFID**

"'The Savi technology works. We can track things from factory to foxhole. What would have taken several days to locate in the first Gulf war, we can now find in 20 minutes.' This technological transformation started only in the mid-90s, but it has led to dramatic efficiency gains. While there are one-third as many troops this time around as Desert Storm, the Army is using 90 percent fewer shipping containers."

- ***Maj. Forrest Burke, Chief of Logistics Information Management for the Coalition Forces Land Component Command, Operation Iraqi Freedom***

[Text and quotes in Fortune Magazine and Federal Computer Weekly, April 2003].

Source Savi Technology

Figures 1.11 1.12 and 1.13 give examples of military active RFID equipment in use.

Fig. 1.11 **Active RFID interrogator deployment in the Iraq war**

Source Savi Technology

Fig. 1.12 **Mobile interrogators in the Iraq war**

Source: Savi Technology

Fig. 1.13 **Write terminal and docking station**

Source Savi Technology

Nevertheless, the US Military is careful to call this "near real-time" monitoring of assets not real time. Its significance comes from the sophistication of the data handling, including linkage with data from billions of barcodes, the sophistication of the tags and the geographical spread of the assets, not in the number of RFID tags, which, at 250,000, is well below the number in many civilian programs. In April 1992, the US Military decided to pursue TAV with considerable investment. To

date, about $600 million has been spent on the core aspects of this program. It had to involve all arms of the service so the term Joint Total Asset Visibility (JTAV) was coined. It is not confined to the modest level of RFID tagging but encompasses all existing data acquisition methods as updating proceeds.

JTAV is the Defense Department's automated information capability for tracking equipment, personnel and supplies. It gives increasingly pervasive information on location, movement, status, identity of units, personnel, equipment and supplies. There is an overarching logistics strategy to support global end to end distribution and visibility capability, to coin the words of the US Military.

The JTAV Office and mission

The JTAV Office is responsible to ensure a JTAV capability is provided throughout the DOD by ensuring JTAV functional requirements are satisfied by DOD-wide automated information systems. It focuses on providing asset visibility in-storage, in-process and in-transit to help optimise DOD's warfighting capability and the ability to conduct operations other than war. The JTAV Office also evaluates the design, development, integration, and implementation of logistics processes, technologies and systems to achieve these requirements. Using active RFID tags (i.e.. with battery for long range etc.), assets are now monitored in 40 countries at 400 nodes at seaports, airports, rail terminals and army bases.

JTAV mission

The JTAV Office ongoing mission is to ensure that the required level of TAV capability is provided to the Combatant Commanders. This includes subordinate Joint Task Force (JTF) Commanders, the Services and DOD activities. The focus of the JTAV Office is on executing the JTAV Implementation Plan in support of this. The JTAV Office performs the central role as the functional integrator. It serves as the proponent for JTAV and will lead and manage the Joint TAV effort DOD-Wide. It ensures that JTAV policies, processes, plans, programs and procedures are fully synchronized, integrated and institutionalised. In this regard, the JTAV Office will also ensure that the planning and execution of JTAV fully supports DOD's Logistics Strategic Plan. The JTAV Office determines the scope of and requirements for Joint TAV at the wholesale, retail and tactical levels of logistics. The JTAV Office facilitates (in conjunction with the other functional communities) the appropriate application of logistics-related C4 systems and related enabling technologies to provide JTAV capabilities and process improvements. The objective is to maximize effectiveness and also achieve related cost savings. Specific responsibilities of the JTAV Office include:

- Refine and clarify user requirements and the JTAV operating concept. Implement JTAV operational and systems architectures.
- Coordinate JTAV initiatives and funding requirements.
- Propose consolidation of DOD TAV initiatives to avoid redundant efforts.
- Maintain a robust sustainable and automated capability.
- Oversee the development, integration, and implementation of JTAV efforts.
- Ensure Combatant Commanders/JTF user requirements, validated by the Joint Staff, are satisfied.

- Manage execution of the JTAV Implementation Plan and advise the JTAV Council on the status of that implementation.
- Explore and exploit technology to provide a JTAV capability DOD-Wide.

Already, the work is extremely comprehensive. Inter alia, it covers:

- War reserves
- Unit equipment
- Food
- Bulk fuel
- Transport
- Ammunition
- Personnel
- Requisition stocks
- Inventory
- Medical

It involves joint warfighting, force preparedness and life cycle management, facilitating the capability to act upon that information to improve the overall performance of the DOD's logistics practices. There is no quest for mountains of indigestible, undigested or useless information here.

Automatic Identification Technology AIT gets great attention. The gathering of information by humans using pens, keyboards and even hand-held barcode scanners is increasingly impractical, inaccurate and expensive given the burgeoning scale of the operation. Information interpretation and fusion using advanced software is vital as are Joint Decision Support Tools (JDST).

Database structure

The Joint Total Asset Visibility program revolves around a centralized database that allows commanders to have total visibility over Army and DOD assets that are stored or in-transit in the supply pipeline. The visibility data is taken from several interrelated databases.

Redistribution is facilitated

The redistribution of assets is a key feature of TAV. The US Military reports that

"The TAV provides the item managers with the capability to identify assets available for expeditious and efficient redistribution through Department of Defense (DOD) supply channels. Information to TAV users includes : Assets (on hand balance, due in/out, substitutes, ownership/purpose codes); required and authorized quantities plus requirements objectives, and on-line catalogue information..."

The TAV allows users to track assets in transit by document number, flight and transportation control number, and in other ways. The TAV also provides visibility of major items down to the property book level and secondary items down to the Direct Support (DS) level.

Near real-time pictures

The US Military reports that "Total Asset Visibility provides "near real-time" pictures of asset availability throughout the supply system. For example, if your unit is short of five-ton trucks or fuel pods, managers can find out where these particular assets are located and they can be redirected to the units that need them. The TAV consists of two elements : asset visibility and in-transit visibility. Asset visibility focuses on inventory resources, In-transit visibility focuses on resources moving through the supply pipeline. All DOD organizations can gain access to the same combat service support (CSS) data as the item manager. Automation and communications link vendors and transporters with the Army's support system to provide more responsive support to the tactical units. The TAV is synchronized and compatible with all active and reserve CSS units, providing horizontal and vertical visibility of assets throughout the system. Distribution Management Centers (DMC) at each level can plan and coordinate delivery of assets. The TAV reduces reaction time, produces quicker order ship times for Class IX repair parts, lowers maintenance down time, and leads to higher operational readiness rating in our units".

The user viewpoint – unclassified read-only data

From the "user" viewpoint, for the US Military, its Total Asset Visibility program is a read-only capability, covering all classes of supply and available to all Department of Defense (DOD) personnel. The data is unclassified and taken from existing data banks at wholesale level and at retail level. "If you own, manage or maintain assets in the US Army today you should be using TAV. It provides detailed information on wholesale and retail assets in storage, in use, in-transit and authorized".

Military opportunities for RFID suppliers

The primary opportunities for suppliers to a military TAV program are systems integration, software and data acquisition systems. For example, Northrop Grumman Information Technology was awarded a $63.8 million contract on 26 September 2002 to design new software, upgrade the existing system architecture and provide support for the upgrade.

Symbol Technologies has landed major orders for barcode-based systems and Savi Technology for Radio Frequency Identification RFID-based systems, including one for $111 million. Both companies are required to provide system integration, software and support in the main but, in future, as active RFID tags are used in much larger numbers – perhaps billions or more yearly – the supply of tags and infrastructure will also lead to large orders.

Links with civilian logistics systems

The US Transportation Command's Global Transportation Network is providing the military with almost instantaneous updates on the location of troops and supplies on the move. It wraps the logistics systems of the services and defence agencies – along with commercial carrier information – into one integrated database. The next project linked to the transportation information technology systems operated by the Defense Department, including the Air Force's Cargo Movement Operations System (CMOS) and those operated by civilian transportation companies. CMOS monitors passengers and cargo to increase in-transit visibility from home bases to the

trenches. There is also a need to link the system to materiel in storage and repair, whether at civilian or military installations.

A spokesman said, "We're working closely with the Joint Staff and other DOD stakeholders as we define asset visibility to the data level and then determine how our transportation systems, policies and procedures in the field can capture that information. That hands-off reporting would allow us to seamlessly process cargo and passenger loads and provide the asset visibility that the warfighter is needing".

1.4. Civilian logistics – Smart and Secure Tradelanes

The civilian freight industry has been tackling severe problems. One is the theft of trucks, often laden with goods up to a value of one million dollars or more is not unusual. Another is costs.

Accounting for freight is inadequate, resulting in over-ordering, over-supply and poor service. Some improvements have been made with hidden electronic boxes in the vehicles that can be tracked, sometimes in real time, and radio tags and other devices on or in the freight itself.

Major active RFID systems, modelled on the US JTAV military system, are now being installed in civilian logistics systems. The largest recent example, initiated in mid 2002, addresses sea containers in the context of the new terrorism.

Over 17,000 sea containers, carrying more than 80 per cent of US imports, arrive daily at US seaports, often located near major cities and industrial centers. The initiative aims to enhance the safety, security and efficiency of cargo containers and their contents moving through the global supply chain into US ports.

Driven and initially funded by industry, this initiative called "Smart and Secure Tradelanes" (SST), is focused on container security and tracking and will be built on existing infrastructure and technologies that are both proven, available for immediate deployment, open and adaptable to enable integration of new "best-of-breed" technologies as they emerge.

The industry-driven SST initiative will demonstrate the principles of the US Customs Container Security Initiative (CSI), Customs-Trade Partners Against Terrorism (C-TPAT), and the US Department of Transportation's Transportation Security Agency's (TSA) maritime security initiative, such as Operation Safe Commerce. Implementation of SST began immediately and was operational by year-end. It involves automated information technology infrastructure linking ports such as Singapore, Rotterdam and Hong Kong with major US ports such as Seattle/Tacoma which is the first domestic port to rollout.

As in the military, the system improves the tracking and security of shipments coming into the United States through electronic event-driven alerts, anti-tamper systems, virtual inspection and authenticated audit trails. The TAV network is built on existing US and international standards and on the Universal Data Appliance Protocol (UDAP), which allows open "plug and play" integration of automatic data collection devices, such as RFID and GPS, along with sensors, scanning and biometric systems.

"We're all motivated by a desire to make sure world commerce remains secure and free of threats", said Coburn, recently retired four-star general and former Commanding General of the US Army Material Command who was instrumental in implementing the TAV network for the US Department of Defense. "The ports and shippers are demanding realistic solutions that can be tested today and adapted and built upon in the future. This is one solution that's been proven to work and will provide a real-life model that both government and industry can leverage and learn from in order to rapidly build an international system for cargo security".

Integrated system

Savi Technology report that, initially, the SST rapid deployment implementation calls for an integrated security and container security system to register individuals, authorize roles, and to capture tracking a security events throughout the supply chain. Working with shippers, carriers, service providers, foreign and US port terminal operators, containers will be tracked and automatically authenticated from the point of manufacturing, port of loading, transhipment port and to final discharge in the US. SST, which will work in close coordination and consultation with government agencies, will develop and test potential auditable security standards for maintaining secure ports, shipping facilities and container tracking and security.

"This is a model for how our nation can improve port security, and I'm proud that the Northwest is on the cutting edge as the first commercial port in the nation to offer this level of security", said Senator Murray. "Because shippers value safety, security and efficiency, Seattle and Tacoma will become even more attractive to shippers worldwide. The new thinking, new technology and new partnerships at work here will result in a more secure and more efficient chain of commerce. This partnership protects our cargo and our ports, and closes the gap that may leave us vulnerable".

Figures 1.14 and 1.15 show the RFID seals and figure shows a reader in operation on a crane. Figure 1.16 shows operation at a customs border crossing

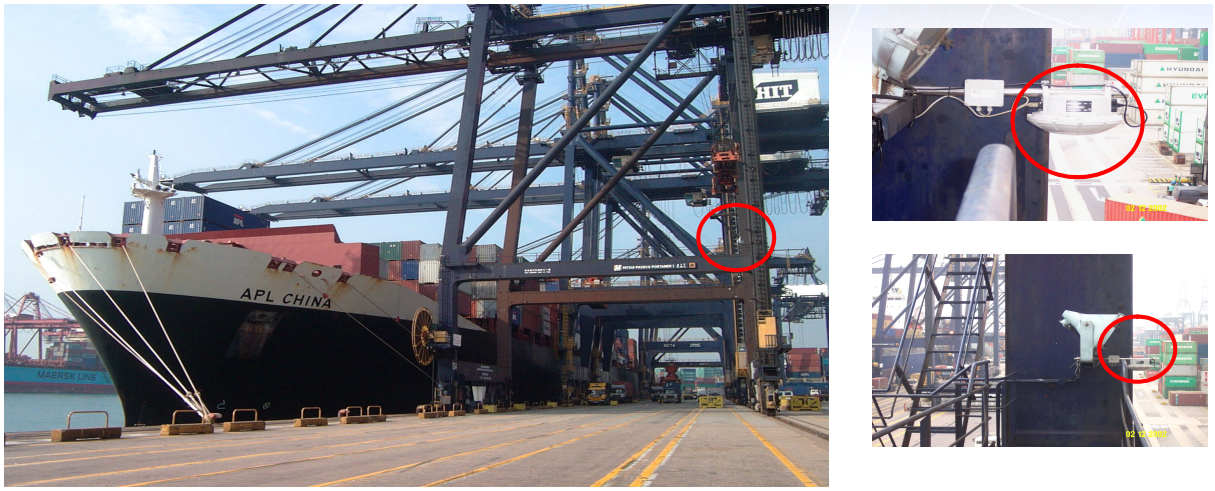
Fig. 1.14 **Sealing and anti-tamper capability with intermodal containers**

Source: Savi Technology

Fig. 1.15 **Smart and Secure Tradelanes active RFID seal being used to lock an intermodal container**

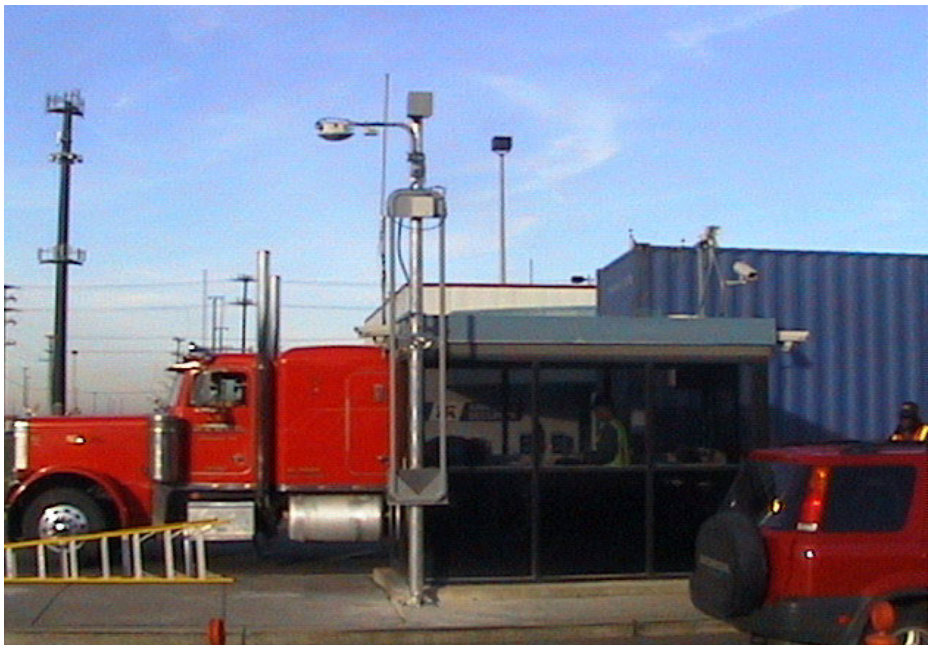
Source: Savi Technology

Fig. 1.16 **Final check of security at dock**



Source: Savi Technology

Fig. 1.17 **Security check of truck at customs point – interrogator monitoring active RFID tag**



Source: Savi Technology

Best in class

Initial port operating companies spearheading Smart and Secure Tradelanes, which together account for 70 per cent of the world's container port operations, are : Hutchison-Whampoa, the world's largest port operating company, managing 30 ports in Asia, Europe, Africa and the Americas, accounting for 40-50 per cent of the total import container traffic in US ports: PSA Corporation, which handles 25 per cent of the world's container transhipment volumes and operates 14 container terminals in nine countries including Singapore, Belgium, Italy, China, India,

and South Korea; and, P&O Ports, one of the world leading port operators with 21 container terminals in 19 countries and 84 ports, including terminals in New York, Baltimore, New Orleans and Miami.

Solution providers involved in the SST initiative are Savi Technology, which helped build and operates the US Military Joint Total Asset Visibility network, which is the world's largest active RFID (i.e. with a battery in the tag for long range operation etc.) tracking system for the US Department of Defense; Sandler, Travis Advisory Services, the international trade consulting firm; Qualcomm, a global leader for mobile fleet management using satellite communications and GPS systems; SAIC, a leading system and technology company for ports and transportation companies, including non-intrusive inspection systems and Parsons Brinckerhoff, one of the largest transportation and infrastructure engineering firms in the world.

Funded by the three port operators, who are also members of the Strategic Council on Security Technology, in Phase One SST will deploy baseline infrastructure, hardware, including electronic seals, sensor devices and sophisticated scanners and web-based software to secure and track containers in near real time.

"PSA Corporation is participating in this project to ensure that we remain on the leading edge of information technologies that can improve the speed, efficiency and security of port operations for the world's carriers and shippers", said Ng Chee Keong, group president for PSA Corporation Ltd.

"The stakes are too high not to take immediate action in using the latest technologies to protect the safety and security of the world's sea ports, through which 90 per cent of world freight moves every day", said John Meredith, group managing director of Hutchison Port Holdings, a subsidiary of Hutchison Whampoa Ltd.

"P&O Ports is pleased to be a key participant in this innovative project, which will undoubtedly help to bring about new standards for supply chain security", said Ned Holmes, Chairman of P&O Ports, North America, Inc. and former Chairman of the Port of Houston Authority.

"The Port of Seattle welcomes the SST initiative", said Mic Dinsmore, Chief Executive Officer, Port of Seattle. "As one of the primary Pacific gateways into the United States, the Port of Seattle must take a leadership role in establishing systems that ensure the safety and security of ocean cargo. SST will make a real difference immediately upon its deployment".

1.5. Five key priorities for TAV

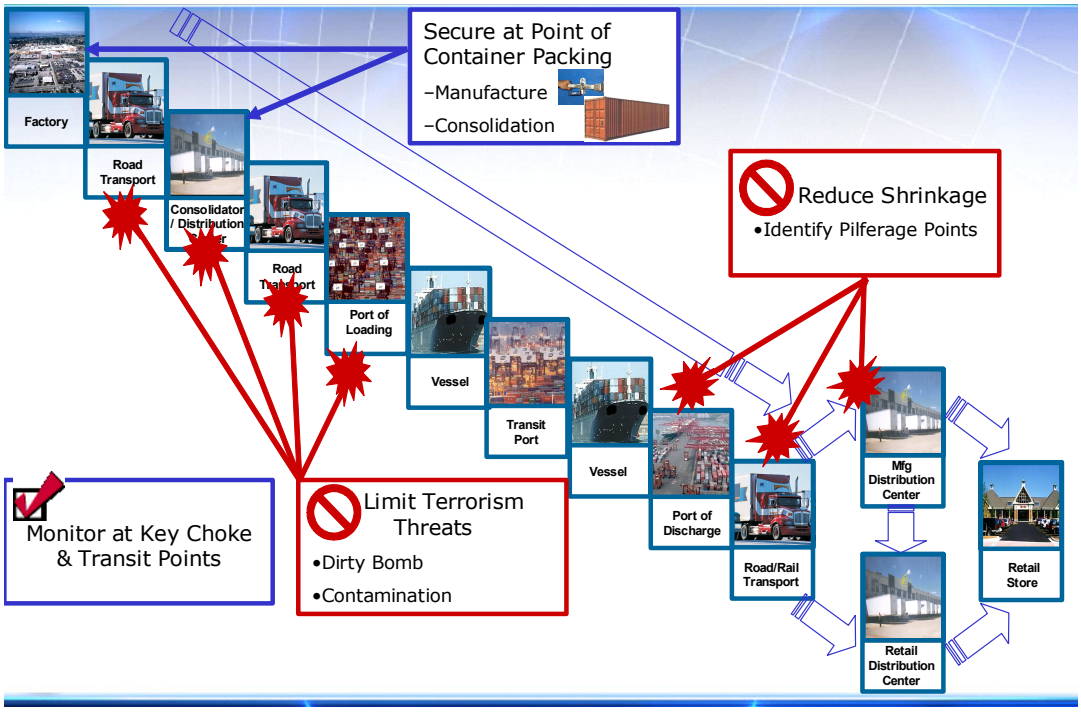
In embarking on a TAV program, five key priorities must be evaluated. This leads to compromises where certain capabilities are prioritised and others are abandoned, at least in the medium term. Otherwise the project becomes unwieldy and unaffordable. The options are:

- Tracking vast numbers – at least hundreds of billions. This means very low cost tags, currently limiting it to passive tags.
- Real time or something near to this, which usually implies active tags.
- Condition monitoring such as signalling immediately when the temperature exceeds a danger point or reporting temperature continuously or detecting theft or tampering as it happens. Usually active tags are needed for this.
- Remote recording of data onto tag e.g. because duplication is prudent or interrogators cannot always be networked. Certain active or passive tags can be rewritten remotely but the active ones can usually achieve this at more than the 0.7 meter range that is the limitation of most passive tags in remote read mode and with more data.
- Remote detection of position. Usually this is only achievable with active tags. There is limited capability with some passive tags but it is limited to 10 meters or less in most real world situations.

No scheme can prioritise all five, yet compromises prioritising two or so of these aspects are common. In addition, particular attention may be needed in identifying each item uniquely (very common) or locating the item very accurately – say to a few centimeters down to one millimeter – which is important relatively rarely. Automated alerting to slight movement is useful with dangerous or valuable items.

Figure 1.18 gives some of the potential benefits throughout the supply chain

Fig. 1.18 **Some of the potential benefits throughout the supply chain**



Source: Savi Technology

1.6. Exponential growth

Over the years, the numbers of items involved in TAV-related RFID schemes has been growing exponentially

While the most important TAV project in the past has been the US Military TAV program, the next important project is the RFID tagging of tens of billions of vehicles, conveyances (such as pallets, bins, crates, ship and air containers), expensive products, multi-packs and air baggage every year. This requires a different tag to that used for 300,000 critical assets by the US Military. It will have no battery i.e. be "passive" and have a range of only1-3 meters with modest data retention, in order to be almost one thousand times cheaper, at 5 cents or so, and small enough to go on small items. Where necessary, it can be used on products and equipment for their whole life, because it has no battery to replace.

The primary reason for doing this is the same as the US Military TAV program – to reduce costs (including crime) and improve service but now including the tagging of smaller, lower cost items in much larger numbers. However, by far the biggest potential for this new application is in the civil sector, not military, the CPG supply chain being the biggest opportunity.

At these volumes, the largest impediment is tag price because, unlike most RFID projects to date, including the US Military program, here the largest component of cost over life will usually be tag cost. A tag cost of 5 cents is needed for the market of tens of billions yearly to open up on paybacks of under two years and frequently under one. Such a tag will be available soon. Software and service costs must come down too. However, even at today's price for this type of tag of 50 cents to $5 in volume and today's infrastructure cost, a market of the order of one billion tags yearly may open up.

Figure 1.19 shows two types of active RFID tag offered by Wavetrend UK for asset tracking and other applications.

Fig. 1.19 **Two types of active RFID tag offered by Wavetrend UK for asset tracking and other applications**

Source: IDTechEx

1.7. Standards

Because the largest RFID projects usually involve open systems, i.e. ones where any service provider can participate provided they obey the rules, standards are important. Traditionally, the development of standards has followed the adoption of RFID – from top down. By this we mean that it was cost effective to tag very expensive things first such as vehicles then, as the cost of the tags and systems came down, it became cost effective to tag cases, pallets, assets in buildings and so on and use the tags on people. Applicational standards were therefore written first for the projects that were feasible first. However, there are several other types of standard such as those covering the way the tag communicates with the interrogator. We discuss standards more thoroughly in section 5.1.

A new bottom up approach

However, we should first introduce the most important standards initiative in recent times - that based on the so called Electronic Product Code EPC. This has its origins in a desire by the leading Consumer Packaged Goods companies to improve their supply and delivery chains by putting a unique radio identity on all items they handle. This could not wait for tag and system prices to gradually come down over the years so a "bottom up" approach was adopted when serious work started in 1999.

The proponents concentrated on a one cent tag for everything in the supermarket and a five cent tag for pallets and cases beforehand – tag price being particularly important because these tags would be disposable and there would be vast numbers per interrogator unlike any RFID that had gone before. Initially, they declared that the price challenge was so great that only the most primitive passive tag would do – one with 96 bits of data that is read-only and passive (no battery). Only an ID number was possible. However, although that may still be true for the objective of the one cent tag to replace all barcodes, it has become apparent in recent years that a hierarchy of tags is needed, including more expensive read-write passive tags and even active tags both read only and read write, indeed some that sense humidity and so on as well.

Active tags have a place after all

The initial view that totally new standards must be written and old equipment abandoned has now given way to a more realistic objective of subsuming the putative standard for data transfer into the existing single ISO standard for RFID data interface called ISO 18000. Within this, standards for EPC passive tags are being written and a so-called Generation 2 sub standard has been prepared that covers active tags. All is not settled, however, and one setback has been the declaration in mid 2004 by participant Intermec that the new standard will require adopters to pay them royalties against patents.

We now look a little closer at EPCglobal, owned by "bar code" standards organisations UCC and EAN, that is tasked with making EPC systems a reality, from writing standards to responding to privacy lobbyists.

1.7.1. EPCglobal

The Internet of Things scheme of standards organisation EPCglobal is based on interrogating tags over the internet and sophisticated software has been developed to enable this, notably:

- Object Naming Service (ONS) – tells computers where to locate information on the internet.
- Product Mark-up Language (PML) – describes physical objects, based on XML.
- Savant™ – distributed architecture for data smoothing, reader co-ordination, data forwarding, data storage, task management etc.

Powerfully, EPCglobal is managed not by suppliers but by users. More than 100 organisations finance the venture, which even embraces academic organisations, called Auto-ID Centres, that are researching different aspects and are situated in the US, UK and Australia, Japan and China. In addition, many major trials are being pursued with the support of the world's largest retailer, pharmaceutical manufacturer, CPG manufacturer, military organisation, postal service etc. Indeed most of them, and a number of other large players, have mandated EPC tagging of pallets and cases by their, typically by the end of 2005 or 2006. EPCglobal and the Internet of things are further elaborated in Appendix 2. However, although EPC is relevant to the largest potential application of passive tags (CPG supply chains) and now embraces active tags, it does not embrace today's

largest use of active tags – car clickers – and it will not necessarily embrace the largest future uses of active tags.

1.8. The $1 billion yearly potential in the prison service

Market potential of one billion dollars yearly can now be identified in many areas of active RFID and here we look at just one of them. It is typical of such niches in that specialist knowledge of the particular applicational sector is essential. One example is the prisons of the world – what the Americans call correctional facilities - and the control of prisoners released on parole. Table gives a summary. We do not assume that the tens of thousands of prisons in the Third World will adopt this technology any time soon.

Table 1.7 **Active RFID in the prison and parole service**

APPLICATION	FORMAT	BENEFIT OF ACTIVE TECHNOLOGY	EXAMPLES OF SUPPLIERS
Tracking prison keys and preventing unauthorized removal	Key fob	Works in bulk metal environment, extensive recording of history	Wavetrend UK Avonwood UK
Tracking staff	Wristband or fob	Long range, tolerance of metal and alarm button can signal alert and radio the location	ELPAS Israel Wavetrend UK X-ident Canada
Tracking and controlling prisoners	Wrist or ankle band	Long range and tolerance of metal, extensive recording capability, real time or near real time monitoring – no need to wait for an interrogator to be near and activated.	TSI Technology (Alanco) US
Monitoring prisoners on parole	Wrist or ankle band signalling to autodial telephone	Tolerance of metal, electrical interference etc, range	TSI Technology (Alanco) US

Source: IDTechEx

Figure 1.20 shows RFID protecting keys.

Fig. 1.20 **RFID protecting keys against theft or misuse.**

Source Wavetrend

New active RFID technologies

There are interesting new advances in RFID relevant to these applications such as the legalization of Ultra Wide Band UWB for RFID in the US in 2003. This has led companies such as Sigma Technologies of the US to launch active tag systems that are claimed to be more sensitive, a benefit that could be taken in longer range or greater tolerance of interference etc. However, this needs proving. UWB in this context is a broad range of frequencies around 6 GHz and narrow beams may be involved that could cause reflection and other problems. Startup Telegesis of the UK claims exceptional range for active RFID without recourse to UWB but none of these new companies can yet show deep knowledge of the prison service and its needs.

TSI Prism

For now, the most sophisticated capability for RFID in the prison service is that of Alanco Technologies' subsidiary TSI in the US. The company describes its capability as follows:

TSI PRISM technology addresses the weaknesses of conventional correctional facilities security and safety with state-of-the-art wireless RFID and tracking technology, providing real-time identification and tracking of inmates and staff at two-second intervals twenty-four hours per day, 365 days per year.

The foundation of the TSI PRISM technology was developed for the U.S. Department of Defense by Motorola, Inc. in the early 1990's. Concurrently, TSI was awarded a methods and use patent incorporating radio frequency technology for locating individuals in confined areas. In conjunction with its own patent and seven (7) licensed patents from Motorola, TSI has conducted extensive product research to miniaturize components of the original system and develop proprietary software programs. In addition, TSI also licenses certain tamper detecting technology from BI Incorporated. To date, approximately $26,000,000 has been invested in the TSI technology, including $9,000,000 by Motorola, Inc. in pre-TSI research and design and approximately $17,000,000 by TSI shareholders. TSI is unaware of any competitive technology capable of real-time RFID tracking of thousands of individuals simultaneously within a confined environment.

The TSI PRISM wireless (RFID) tracking system consists of five primary components: a tamper detecting wristwatch-sized RF (radio frequency) transmitter for inmates, a belt-mounted transmitter worn by the officer staff, a strategically placed array of receiving antennae, a computer system and TSI's PRISM application software. TSI's proprietary algorithm software simultaneously processes multiple thousands of unique radio signals received every two seconds from the wrist and belt worn transmitters to pinpoint an individual's location and track that individual in real time as they move about the facility. Entry into a restricted area or attempts to remove the transmitter device signal alarms to the monitoring computer. The officer transmitters can also signal an alarm by manual activation of an emergency button, or automatically, if the officer is knocked down or the transmitter forcibly removed from his belt.

TSI's technology provides much more than real-time individual identification and tracking with its array of database and software applications. The system automatically records all tracking data

over a prescribed period in a permanently archived database for accurate post-incident reporting and future reference. A host of management reporting tools are available that include medicine and meal distribution, adherence to pre-determined time schedules, restricted area management, and specific location, arrival and departure information.

Initial $1.4 Billion Market Opportunity: Corrections Industry

The corrections industry represents the largest initial market opportunity for the TSI PRISM technology. According to the U.S. Department of Justice, there are over 5,000 correctional facilities in the United States and Canada. The initial target market for the TSI PRISM system is the approximate 1,400 existing minimum, medium and close security Federal or State prison facilities with over 500 inmates each that cumulatively represent a $1.4 Billion market potential. Larger populations, greater facility density and new facility construction demand modern management tools.

The number one priority of corrections administrators is the safety and security of the public and their officer staff. The industry has embraced and employed numerous technology advances aimed at this priority concern. Nothing offered before, however, improves security to levels possible with TSI PRISM's real-time tracking of inmates and staff throughout a facility coupled with instantaneous alarm activation by a triggering event, such as wristband removal.

TSI PRISM serves to reduce escape attempts and incidents of inmate violence simply due to the inmates' perception of being watched 24/7, providing potential savings in medical, litigation and investigation expenses. A single escape, for example, can cost up to hundreds of thousands of dollars if sheriff, municipal and state police are called in to search for the escapee. The archived database, which can prove unquestionably which individuals were in a specific area at the precise time of an incident, can also result in significant cost savings relative to investigation and legal expenses.

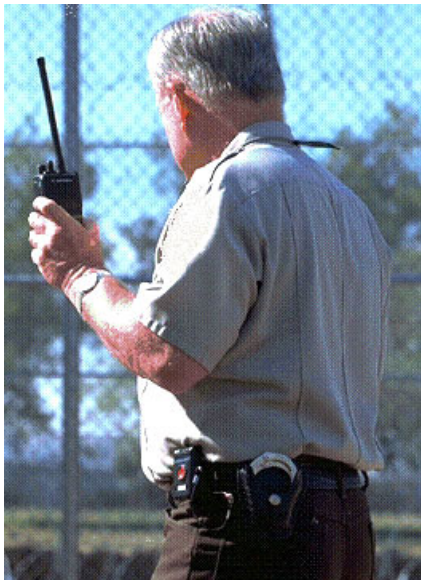
TSI PRISM also performs a perfect inmate "head count" every two seconds! Potential productivity improvements and cost savings are possible through reducing the centuries-old practice of manually counting inmates 5 to 10 times per day. Deployment of the TSI PRISM system also can result in cost savings through reduction or elimination of other expensive facility security equipment and/or procedures, such as armed guard towers, electrified fences and other costly perimeter security devices.

The State of California is recognized as a national leader for the corrections industry, particularly relative to new technology application. Following six years of extensive research, product development and beta testing, California has cooperated with TSI since early 2000 to operate a pilot site at a minimum-security facility in Calipatria, California. Larry Cothran, Executive Officer of the Technology Transfer Committee, California Department of Corrections, has stated, "The TSI PRISM technology will change not only the way inmates live, but how staff run the institutions. This will revolutionize prisons in California and nationwide." *(As quoted in CDC's Correction News.)*

Fig. 1.21 **Wristwatch transmitters worn by inmates**

Source: TSI Prism

Fig. 1.22 **Belt transmitters worn by officers and staff**



Source: TSI Prism

Operation:

The operation of the system is as follows: Transmitters worn by staff and inmates emit RF signals at two second intervals that identify each inmate and staff member. These signals are received by multiple active antennas which route them via coaxial cable to collector nodes. Here the

information is processed, stamped with time of arrival data and retransmitted to the server computer. The server's application software uses the data to compute the position of the transmitter. It also, stores the information, creates alarms for exception conditions, and provides all this information to the client terminals. Client computers provide a means of displaying that information in a variety of ways and a robust method of recording the staff's response to exception events.

Features

- Provided that individuals are tagged and remain within the monitored area, the system is able to:
- Record the location of all inmates and staff at two second intervals
- Count the enrolled population every few seconds and create an alarm if anyone is missing
- Create an alarm if an inmate transmitter has been removed or tampered with
- Create an alarm if an inmate enters a restricted area
- Create an alarm if an officer signals for help
- Identify and track individuals that were near any alarm event
- Automate egress and ingress procedures
- Locate individuals on demand
- Identify inmates who attempt to double back at the cafeteria
- Identify inmates for commissary purchases

2. Lessons from case studies of active RFID

2.1. Spread of parameters and applications

We have chosen to insert only one of the organisations buy-ins active RFID auto-dialler alarms for the disabled. To include all the hundreds of such organisations would have distorted the figures.

2.1.1. Military, Logistics and Automotive/ transportation are dominant applications so far

The largest spend on active RFID systems has been in Automotive with about $1000 million on car clicker systems (solely tags and interrogators – there is no computer system involved here). Next comes $600 million in military applications of which about $100 million has been spent on the Military active tags and interrogators, the rest being spent on integration with legacy systems, other infrastructure, software, training, maintenance, upgrades and systems integration. In mid 2004,The U.S. Dept. of the Army awarded Intermec Technologies a prime contract to provide mobile computing and automatic identification systems, wireless networking technologies and services worth as much as $238 million over the next five years. The contract, administered by the U.S. Army, will provide equipment, systems and services to all branches of the U.S. Dept. of Defense worldwide. It is part of its Automatic Identification Technology initiative, a basic building block in the department's efforts to provide TAV in its global logistics pipeline, whether in process, in storage or in transit. Under the terms of the five-year technology contract known as AIT-III, Intermec will supply a complete line of advanced mobile computing, wireless communications and data collection systems and services, all engineered to meet the most demanding military applications and deliver efficiency and productivity. Intermec has teamed with Northrop Grumman on the project. The active RFUID content of this has not been announced, nor even the percentage that is RFID of any sort but it is once again an indication of the substantial spend by the US military in

RFID and allied matters. In both Automotive and Military active RFID, almost all the spend has been in the last ten years. The largest number of active tags sold has also been in Automotive – notably car clickers.

Largest sectors

In the following analysis of case studies of active RFID, the largest number of projects we have located has been in Logistics at roughly double the number for each of the next contenders - the Air Industry, Automotive/ Transportation and Healthcare sectors. However, if we had counted each of thirty car manufacturers using car clickers rather than counting them as one, then automotive/ transportation would have been in the ascendant. Of course, some projects could be classified under several alternative categories and some sectors are relatively secretive , so these may be under-represented.

Figure 2.1 shows an RFID tag shaped like a watch that is used to prevent the disoriented mental patient from wandering into dangerous areas such as the kitchen or the street. It can lock doors ahead of them or call a carer for example.

Fig. 2.1 **Active RFID wriststrap to protect disoriented patients**

Source: XMark Systems

2.1.2. Containers and vehicles are the main items that are tagged

The items that are tagged were mainly containers, followed by vehicles, conveyances and people. Car clickers are products in their own right of course and do not tag anything. Tagging of people is nonetheless a significant and growing sector.

2.1.3. Frequencies are varied

In our study, the frequencies used were surprisingly varied, even for similar applications. For example, locating vehicles may be done at four or more widely different frequencies. Indeed, the frequency seems to correlate more with the supplier than the application. For example, TagMaster, Transcore and WhereNet concentrate mainly on 2.45GHz, Savi on 433 MHz and Avonwood on 125 KHz all for tags where the battery boosts the range. For semi-passive tag systems, KSW Microtec has preferred 13.56MHz. However, 433 MHz is the most popular frequency for active RFID overall at present, mainly driven by the preferences with car clickers and military applications. These are semi-active applications.

2.1.4. Ranges are varied

Ranges are varied but the distribution, which is approximate because of data uncertainties, is as shown in table 2.1. The choice of frequencies narrows to the higher frequencies as range requirements increase.

Table 2.1 **Approximate distribution of case studies by range.**

MAXIMUM RANGE METERS	APPROXIMATE PERCENTAGE OF ALL CASE STUDIES	SOME OF THE REASONS	MAIN FREQUENCIES
Up to 5	45	Semi-passive tags only have short range. Need to distinguish between tagged items that are no bigger than a person	125-135 KHz, 13.56, 132 MHz, 433 MHz, UHF, 2.45 GHz
5 to 30	35	Need to monitor passing vehicles without confusing them	433 MHz, UHF, 2.45 GHz
30 to 300	20	Locating large items such as vehicles and intermodal containers at a distance	UHF, 2.45 GHz

Source IDTechEx

Active tags are rarely used either below one meter range or above 700 meters. Positioning using techniques such as triangulation is a rarity in RFID as yet but geofencing (monitoring movement between areas by having interrogators at entry and exit points), as an example, is commonplace. This is a lower cost, but less reliable, alternative to positioning using beams. By less reliable, we mean that geofencing may involve interrogators at doors when a thief may use a window, for instance.

2.1.5. Totally new types of battery

Standard batteries available in shops are the most common form in active RFID so far. Of these, button batteries, otherwise known as coin batteries, are the most popular followed a long way behind by standard cylindrical batteries. Most are fitted so they can be replaced and the most common replacement time is 3-7 years. A minority of batteries are sealed into the RFID tag permanently and the whole tag is then disposed of in 3-7 years in the main.

2.1.6. The most important countries

In our sample, by far the largest number of active RFID projects are in the USA. The UK comes next followed by a wide variety of countries well behind.

2.2. Case studies of active RFID in manufacturing

2.2.1. Volkswagen, Germany – work in progress

Company Volkswagen Germany	Application Manufacturing
Benefits Sought Error reduction Cost reduction	Status Roll–out (Complete)
Tag Supplier: Identec Format: Active Read/Write	Interrogator: Identec System Integrator: Identec
Further Information Identec: www.identecsolutions.com	

Report
In a 2003 lecture - 'The Value of Long Range RFID Technology in the Automotive Industry' Gerhard Schedler from Identec talked about the current applications being implemented at Volkswagen from their manufacturing right through to delivery of the car. Their system of tracking is done via the ILR® RFID technology, which with a tag price of Euro 25 has a read/write range of 100 meters, using definable memory up to 32 kBytes, identification of up to 100 tags, and a battery life of up to 6 years at 600 readers/128 bit per day. A Volkswagen car goes through 28 steps in the manufacturing process and using ILR® RFID technology you can check that it has gone through the whole process without missing a stage out. Gerhard also talked about the advantages of tracking cars. In a large factory you may have thousands of blue Passat's sitting in identical rows. How do you find the particular cars you want? Each Passat is currently equipped with an ILR®-Transponder mounted at the rear view mirror. Searching cabs are equipped with mobile ILR® - interrogator and data from the cars is transmitted via WLAN When the specified car is located the LED tag on the car flashes, an acoustic signal is heard in the cab and the car has been found. The efficiencies to the factory and eventually to the customer are immense, with improved quality and a faster response time, online status of every car and a quick way of identifying any bottlenecks. The process can also be applied to tracking buses in large depots, finding golf carts on golf courses, and container tracking.

2.2.2. Peugeot, France – work in progress

Peugeot, car manufacture, France
Jul 14, 2004

Traceability for the Peugeot 206 & 307

Company
Peugeot
France

Application
Manufacturing

Benefits Sought
System automation, Inventory control, Speed, Efficiency

Status
Roll–out (Complete)

Tag
Supplier:
Avonwood
Frequency:

LF (132 KHz)

Format:

Active

Read/Write

Button

Range:
1m
Price:
A few dollars*
Number of Tags:
Over 2000

Interrogator:
Avonwood
Interrogator Price:
A few thousand dollars*
System Integrator:
Avonwood
Project Cost:
2 years*

Further Information
Avonwood: www.avonwood.co.uk
*IDTechEx estimate

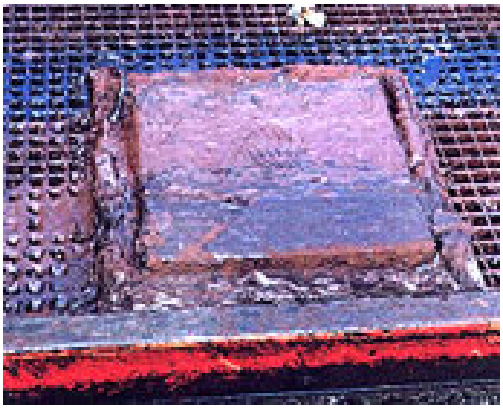
Report
Traceability for the Peugeot 206 & 307
Avonwood report as follows © Avonwood developments
An important aspect of vehicle manufacture is to be able to deliver to a dealer network accurately and on time, a wide range of vehicles to a consumer orientated customer base. This means that, from a scheduling point of view, there must be a reliable means to provide the dealers with up to date information on orders that are placed.

Vehicle manufacturers are very proactive in investing in the latest technology to ensure they remain efficient and effective in an extremely competitive market. Utilising state-of-the-art technology demonstrates a commitment to customer care, and, in an industry where costs are closely monitored, selecting automatic identification, in particular RFID, provides the high level of control needed.

Peugeot Car Plant, Poissy France
The Peugeot car plant at Poissy began manufacturing in the 1940's and has been building cars ever since. The plant aims to manufacture 1,000 cars every day with a target of more than 200,000 cars a year.
Integral to their automated systems are a network of over 80 Eureka Decoders which process data from in excess of 2000 Eureka 415 Read / Write Tags. These Tags are fitted to the bare chassis of a car at the start of the production line, and follow the car through the complete build process.
Every point of identification is connected via a serial link to the Peugeot manufacturing system main frame , which monitors and controls the information received from the Eureka 415 Tags.
The Eureka 415 Tag
Each Eureka 415 Tag operates in a high temperature environment as a radio frequency read-write transponder. The Tag's thermal characteristics enable it to be used for extended periods in conjunction with appropriate cooling cycles, typically 200°C for 1 hour.

It is normally in a quiescent state, but when it comes within range of a radio frequency field produced by the interrogating antenna, it is activated and transmits its data back to the decoder via the antenna. The radio frequency communications to and from the Tag, utilise low frequency inductive coupling, and can therefore function through most non-conductive materials, allowing Tag operation in very difficult and harsh environments. A long-life lithium battery maintains the Tag's data memory, and provides the small amount of power needed to transmit data from the Tag. Because of this the Tag is referred to as an "Active Transponder".

System Operation
Peugeot cars are built to a production schedule based on order intake from a dealer network spread throughout Europe.
At the start of the production line a Eureka 415 Tag is fixed to the chassis of every car body providing a unique ID. This is then used to track the build of the car on a power-and-free conveyor system via several antennas', which activate and receive data from the Tags.
At several points on the production line, including before and after the paint ovens, the Eureka Decoders are instructed, via their antenna's, to read and/or write data to and from the Tags, sending the result to the controlling system, which is linked to the manufacturing database.
At the end of the production line just prior to the car being driven off for road tests the Tag is removed and recycled for further use in the plant.



Conclusion
By using Eureka 415 Active Tags to uniquely identify car bodies the intricacies of production scheduling are streamlined and automated.

2.2.3. Club Car, USA – work in progress

Company Club Car USA	Application Manufacturing
Benefits Sought System automation, Speed, Cost reduction	Status Roll–out (Complete) Start: 1999
Tag Supplier: Identec Frequency: UHF (916.5 MHz) Format: Active Read/Write Price: $5-6	Interrogator: Identec System Integrator: ICE Automation Group
Further Information Identec: www.identecsolutions.com	

Report
Club Car is based in Augusta, Ga., and produces over 100,000 golf and utility vehicles a year. In 1999, the company upgraded its entire manufacturing process and chose to incorporate RFID technology in order to speed up production of a new model of golf car it was about to start producing - the "Precedent Golf Car". The new production line went live in October 2003, and the introduction of RFID technology was one of the factors in cutting the build time for each vehicle from 88 minutes to just 46, as well as ensuring that each car is built to exact specifications.

Club Car's old production line used bar code labels attached to each car and workers used handheld barcode readers to track the vehicle, which was manually pushed around the factory shop floor between workstations. The factory produces both gas-powered and electricity-powered vehicles ,with the two types of vehicle needing different types of construction.

The new production line is a loop of around 1,800 feet, with 46 workstations positioned around it. Each workstation has been equipped with an RFID interrogator that can read a tag attached to the carriage before it reaches the work area as well as when it is actually in the area.

When a carriage first enters the production line, an RFID interrogator automatically scans its tag and a worker also scans a bar code on the vehicle's drive train, using a handheld device. The car being built is automatically associated with those two numbers.

As a carriage approaches a workstation, its RFID reader identifies the carriage by reading its tag. Each workstation has a PC that links to the manufacturing execution systems to control what tools can be used and what parts need to be fitted to each vehicle. This allows the company to build each car from scratch in a single trip through the production line, as opposed to having to build basic cars, send them to a storage yard, then bring them back in to add customised accessories, as under the old system. Two screens at each workstation display the work that has to be carried out by the operator and the carriage cannot move out of the workstation until all the required work has been completed.

2.2.4. AM General, USA – part replenishment

Company AM General USA	Application Manufacturing
Benefits Sought Cost reduction, System automation	Status Roll–out (Complete) Start: 2004
Tag Supplier: WhereNet Frequency: LF (125-135 KHz) Format: Active Read/Write Integrated	Interrogator: WhereNet
Further Information WhereNet: www.wherenet.com	

Report
AM General Corp. makes High Mobility Multipurpose Wheeled Vehicles, better known as Humvees and Hummers. In 2004, the company announced that it had implemented a wireless replenishment system at its factory in Mishawaka Indiana.

The intention of the project is to improve assembly line and shop floor operations. This was particularly to aid with production of the Hummer H2, a vehicle that was designed by General Motors Corp, which AM General manufactures. AM General's factory has produced 60,000 Hummer H2's since production began in spring 2002, and is designed to product around 40,000 annually.

The system AM General has chosen is WhereNet Corp's WhereCall wireless parts-replenishment system. 500 WhereCall devices have been acquired for the project. Each container of parts is associated with a wireless WhereCall device, which transmits its unique identification when an operator presses a call button on it. This transmission is received by a network of 18 WhereNet antennas that are strategically installed at ceiling height within the plant. The system also uses more than 60 active radio frequency WhereTag transmitters and 50 WherePort devices.

This wireless replenishment system project also employs Cimplicity Tracker software, which is ANSI/INCITS 371 compliant and helps leverage WhereNet's wireless location infrastructure.

"Through lower operating costs, AM General has already realised a return on its investment and the applications continue to pay big dividends each day" Deborah Cafiero, CIO and director of information systems AM General, stated.

2.2.5. Merrimac Industries, USA – tracking folders

Company Merrimac Industries USA	Application Libraries and archiving
Benefits Sought Error prevention, Cost reduction, Speed	Status Roll–out (Complete)
Tag Supplier: Axcess Inc. Frequency: UHF (433 MHz) Format: Active Read/Write Label	Interrogator: Axcess Inc. System Integrator: Axcess Inc.

Report
Merrimac Industries designs, manufactures and assembles microtechnology and RF microwave components, sub-assemblies and integrated modules for the worldwide defence, satellite and wireless communications sectors.

Merrimac is using Axcess' ActiveTag to track intellectual property throughout its building and to decrease the time needed to complete quoting. The system provides automatic identification, location and tracking of folders containing customer quotations, engineering documents and drawings, and project notes.

An RFID asset tag is affixed to each folder, allowing it to be tracked throughout Merrimac's 50,000 square foot building as it is processed through each department. The tagging system provides automatic identification, location, and tracking of folders that contain customer quotes, engineering documents and drawings, and project notes. An asset tag is affixed to each folder allowing its whereabouts to be monitored throughout the 50,000 square foot building as the folder is processed through each department. The press release says:
"The ActiveTag(TM) system has reduced the amount of time it takes to complete the customer quoting process," commented Jayson E. Hahn, Vice President of Information Technology and Chief Information Officer. "We were looking for a way to track quotes throughout the process and locate bottlenecks. As a result of attaching the tags to the files and monitoring the folder's movement between departments, the time it takes to complete the quoting process has decreased, which has translated into both cost and time savings for Merrimac."
"We continue to see an increase in awareness of the need to protect assets, both physical and intellectual," said Ben Donohue, Vice President of Business Development for AXCESS Inc. "Here; Active RFID is showing its versatility by improving efficiency and streamlining processes. We are very proud to provide a reliable application of the system to Merrimac Industries."
The ActiveTag(TM) implementation at Merrimac Industries includes small, battery powered RFID asset tags (called generically "active" tags), that when automatically activated transmit a wireless message typically 30 to 100 feet to palm size receivers. The receivers are connected to the existing corporate network and the identification information is imported into Merrimac's MRP system.
The AXCESS ActiveTag(TM) system is used for a variety of security applications including automatic personnel access to facilities, automatic vehicle access to parking areas and yards, corporate asset tracking and protection, as well as special purpose sensing. Automatic e-mail alerting and paging is offered for rapid response to security incidents.
More information is available from the Company's Web site at www.axsi.com.
About Merrimac Industries
Celebrating its 50th anniversary, Merrimac Industries, Inc. (AMEX: MRM - News) is a leader in the design and manufacture of Multi-Mix PICO(TM) RF Microwave components, assemblies and micro-multifunction modules (MMFM), serving the wireless telecommunications industry worldwide with enabling technologies for space, defence and commercial applications. Merrimac is focused on providing Total Integrated Packaging Solutions® with Multi-Mix® Microtechnology, a leading edge competency providing value to our customers through miniaturization and integration. The Multi-Mix® process for microwave, multilayer integrated MMFM circuitry is a patented method developed by Merrimac Industries based on fluoropolymer composite substrates. The fusion bonding of multilayer structures provides a homogeneous dielectric medium for superior electrical performance at microwave frequencies. The bonded layers may incorporate

embedded semiconductor devices, MMICs, etched resistors, passive circuit elements and plated-through via holes to form a three- dimensional subsystem enclosure that requires no further packaging. Merrimac Industries facilities are registered under ISO 9000, an internationally developed set of quality criteria for manufacturing operations.
Merrimac Industries, Inc. and its subsidiary Filtran Microcircuits Inc., are located in West Caldwell, NJ, San Jose, Costa Rica and Ottawa, Ontario, Canada, and have approximately 230 co-workers dedicated to the design and manufacture of signal processing components, gold plating of high-frequency microstrip, bonded stripline and thick metal-backed Teflon (PTFE) micro- circuitry and subsystems providing Total Integrated Packaging Solutions® for wireless applications. Merrimac (MRM) is listed on the American Stock Exchange. Multi-Mix®, Multi-Mix PICO(TM), MMFM® and TotalIntegrated Packaging Solutions® are trademarks of Merrimac Industries, Inc. For more information about Merrimac Industries, Inc. and Filtran Microcircuits Inc., please visit http://www.merrimacind.com and http://www.filtranmicro.com.
About AXCESS Inc.
AXCESS Inc. (OTC Bulletin Board: AXSI - News), headquartered in greater Dallas, Texas, provides RFID (radio frequency identification) systems for physical security and supply chain efficiencies. The battery-powered (active) tags locate, identify, track, monitor, count, and protect people, assets, inventory, and vehicles. AXCESS' Active RFID solutions are supported by its integrated network-based, streaming digital video (or IPTV) technology. Both patented technologies enable applications including: automatic "hands-free" personnel access control, automatic vehicle access control, automatic electronic asset management, and network-based security surveillance. AXCESS is a partner company of Amphion Capital Partners LLC. More information is available at www.axsi.com.

2.2.6. BMW, UK – work in progress

Company BMW UK	Application Manufacturing
Benefits Sought Efficiency	Status Roll–out (Complete) Start: 2001
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read/Write	System Interrogator: TagMaster
Further Information TagMaster: www.tagmaster.com	

Report
TagMaster received an order of 2.3 million SEK from BMW in 2001. Against this, TagMaster delivered equipment for a new production facility in Great Britain where BMW was producing the new Mini Cooper.

2.3. Case studies of active RFID in transportation and automotive

2.3.1. 30 major car companies – vehicle immobilisers

Benefits sought: convenience, security

Status: Ten years of experience

Tag supplier: Sokymat, Texas Instruments etc.

Format: key fob read only

Frequency: usually 433 MHz

Range: 30 meters

Price: about $2

Interrogator supplier: Sokymat, Texas Instruments etc

Price : about $3

System integrator: the car manufacturer

2.3.2. Shanghai Xinzhuang Bus Terminal, China – tracking buses

Company Shanghai Xinzhuang Bus Terminal China	Application Passenger transport
Benefits Sought System automation, Cost reduction, Speed	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only	Interrogator: TagMaster

Report
In Shanghai, China, there are 200 bus lines, with many thousands of buses and there are generally many lines in each terminal. Traditionally, the administration of these buses - collecting information, sorting enquiries, analysing statistics,

creating summary reports and dispatch ordering, has been carried out manually in each terminal. This process was time-consuming and prone to errors, and caused inconvenience to both staff and passengers. It also meant that the bus fleet had to be larger than was actually needed to run the services, since buses would need to be available to cover for those buses that were parked up while some administrative procedure was being undertaken. In addition, a lot of expensive ground was needed for the parked buses.

The Shanghai Xinzhuang Bus Terminal now uses a long-range RFID system from TagMaster. Each bus is fitted with a 2.45 GHz tag and, without the bus having to stop, its ID number and arrival time is registered by an interrogator at the Terminal entrance. Departure information is displayed to passengers on large screens at the depot.
The system also automatically sends dispatch signals to drivers on the buses, and creates statistical reports on bus arrival and departure times, etc.

2.3.3. ProEda, Switzerland – gasoline pumps

Company ProEda Switzerland	Application Passenger transport
Benefits Sought Convenience Cost reduction Crime reduction	Status Trial successfully completed
Tag Supplier: Legic Identsystems Frequency: UHF (433 MHz*) Format: Active Key fob *IDTechEx estimate	

Report
In mid 2003, Legic Identsystems of Germany signed an agreement with the Swiss manufacturer of automated gasoline pumps, ProEda, to integrate its RFID tags into the new generation of pumps. This is probably the first inroad of cashless fobs into the gasoline markets of Europe. Such systems are numerous in the United States, with Exxon Mobil SpeedPass in the lead.

2.3.4. NedTrain, The Netherlands – wheel maintenance

Company NedTrain Holland	Application Passenger transport
Benefits Sought System automation, Error prevention, Speed, Cost reduction	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only Range: Up to 5 meters	Interrogator: TagMaster System Integrator: TagMaster

Report
Damage to train wheels can be extremely serious, potentially leading to disastrous accidents. It is therefore vital that any excessive wear or crack in a train wheel or axle is discovered and rectified as quickly as possible. In the Netherlands, each train belonging to the national rail company, NedTrain, has to have a wheel inspection every three months, which previously meant the train being brought out of service while each wheel and axle was carefully checked at a repair shop. This was a time-consuming and costly operation for the train operator.

All Dutch passenger trains have now been equipped with TagMaster RFID tags to help with wheel quality checks. Long-range interrogators have been installed at 17 checkpoint locations throughout the country, as well as computers that register vibration and weight.

Identification of the train takes place at speeds of up to 160 km/h and the train's vibration and weight results are also recorded at the same time. In order to monitor the exact passing time, TagMaster has developed software that allows the wheel identity to be paired with relevant measurements automatically. If a deviation from the specified quality standards is detected, it is reported via an online telecommunication link to NedTrain's maintenance situation, enabling the company to make a decision on whether or not the wagon should be taken out of service.

2.3.5. Tracker/ Police, UK – locating stolen vehicles

Company Locating stolen vehicles UK	Application Passenger transport
Benefits Sought Crime reduction	Status Roll–out (Complete)
Tag Supplier: Tracker Frequency: UHF (433 MHz) Format: Active	Interrogator: Tracker System Integrator: Tracker

Report
The UK has the highest level of car theft in Europe. One car is stolen every minute. However, the "Tracker" RFID device hidden in a car permits it to be traced even when it is in an intermodal container for shipping to Continental Europe - a favourite practice of the thieves.
All 52 police force regions in the UK have Tracker interrogators and 9,000 vehicles have been returned to their owners in this way. Retrievals are running at £1 - 3 million per month. Tracker is installed for £199 unit cost plus fixing fee and £99 per year is paid for the service.

2.3.6. Hills, UK – numberplates

Company Hills Numberplates UK	Application Passenger transport
Benefits Sought Crime prevention	Status Trial (Ongoing) Start: 2004
Tag Supplier: Identec Format:	
Active	
Read Only	
Further Information Identec: www.identecsolutions.com	

Report
Hills Numberplates Ltd is the market leader in the production of UK vehicle registration plates. The company's e-Plates project, which has been in development since 2001 at a cost of over £1 million, involves embedding active RFID tags into number plates, enabling vehicles to be tracked in real-time. A number of Administrations are currently considering the e-Plate system, and it is hoped the UK Government may adopt it.

The tags for the project will be provided by Identec and will be embedded into an e-Plate the same size and shape as a conventional plate. The plate is permanently fitted to a vehicle after production and can be read at speeds of up to 200 miles per hour by a network of fixed roadside interrogators and portable or handheld interrogators for use in surveillance vehicles. When a tag is read, its unique identifier is sent to a secure central database, where it is compared with the corresponding vehicle data such as make, model, colour, registration number, owner details and tax and insurance details.

Key benefits

The e-Plate system can be used to assist in such areas as:
Security and access control - it can provide better control without the need for cards, keys, cameras or human intervention
Tracking
Traffic management - monitoring and modelling traffic flow
Customer service
Enforcing compliance with road tax, insurance and mechanical check legislation
Combating vehicle theft and related crime
Electronic payment

2.3.7. Ford, USA – location of new cars

Company Ford Motor Company USA	Application Passenger transport
Benefits Sought Time saving	Status Roll–out (Complete)
Tag Supplier: WhereNet Frequency: UHF (UHF (near 90 MHz)) Format: Active Read Only	Interrogator: WhereNet
Further Information WhereNet: www.wherenet.com	

Report
The Ford Motor Company uses 300 meter range WhereNet tags to keep a real-time inventory of thousands of vehicles stored in their huge depots. Details of the car are kept on record, so when a certain specification model needs to be retrieved its location can be quickly identified. The location systems work by using a minimum of three reader antennas. The tags are set to send out a short signal at pre-determined times, say every five minutes. The reader antennas measure the time taken for the signal to reach them, and a processor unit can then give the location of the tag.

2.3.8. Postauto Bus, Switzerland – bus terminal management

Company Postauto Bus Switzerland	Application Passenger transport
Benefits Sought Error prevention, System automation, Customer service	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only Card	Interrogator: TagMaster

Report

Postauto Bus is Switzerland's major bus service operator. The company wanted an accurate method for providing information to its passengers using the Bern bus terminal. As with many bus companies, due to operational variations Postauto's buses did not always arrive and depart at bus terminals at the exact times stated on the timetables, resulting in delays and frustration for passengers. Postauto needed a system that would automatically identify its buses, track their movement and update the timetables accordingly.

As well as Postauto's own buses, several independent bus companies operated from the same terminal from time to time and on a short-term contract basis, so it was important to use a vehicle identification system that did not require a permanent installation on the buses.

RFID system

The RFID vehicle identification system that is now in operation at the terminal in Bern uses 16 TagMaster interrogators - two on each of the seven bus platforms, one identifying arrivals and the other recording departures.

RFID tags are linked to a specific bus route and work shift, rather than a particular driver and/or vehicle. When a driver begins his shift, he collects an RFID tag and places it in a holder mounted on the vehicle's windshield. The correct arrival and departure time for each route is recorded by the interrogators and is displayed on screens at the bus terminal and also at Bern's railway station. At the end of his shift, the driver removes the tag from the windshield holder and it is replaced by a different tag brought by the new driver, who may be driving the bus along a different route.

2.3.9. Tranz Rail, New Zealand – freight management

Company Tranz Rail New Zealand	Application Passenger transport
Benefits Sought System automation, Error reduction, Improved data capture	Status Roll–out (Complete)
Tag Supplier: Avonwood Frequency: LF (132 KHz and 66 KHz) Format: Active Read/Write Integrated Range: 2.5m Price: $20* Number of Tags: 10,000	Interrogator: Avonwood
Further Information Avonwood: www.avonwood.co.uk *IDTechEx estimate	

Report

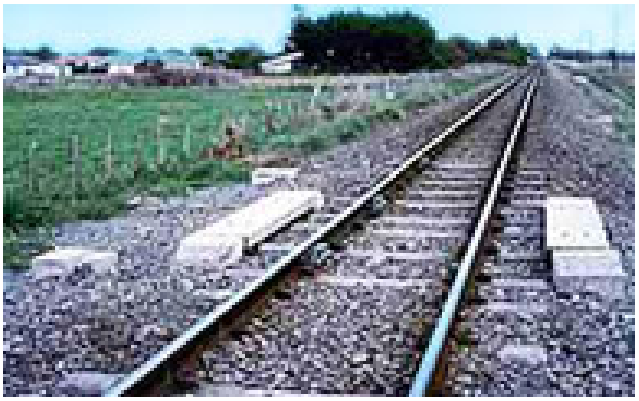
Source Avonwood

Tranz Rail is the leading multi-mode transport company in New Zealand, offering an integrated national network of rail, trucking and ferry services. Tranz Link is the brand name of Tranz Rail's freight transport operations.

Tranz Rail has developed and installed a fleet and freight management system for Tranz Link. The system combines Eureka 811 tags (supplied by Avonwood) and the Coupled In Motion Weighing system (computerised weighing technology) to create an Automatic Vehicle Identification system that identifies and weighs train wagons while they are in motion.

Tranz Link uses the Fleet and Freight management system, provided by Amicus, to collate the load and train information. The addition of RFID tags enhances this system by enabling Tranz Rail to match supply and demand for wagons much more accurately.

Once a wagon has been loaded, the system produces a waybill for that consignment and then uses its files of train schedules and timings to calculate the best route and allocates the consignment to a particular train. A report on the train's load, wagons and destination is produced and yard staff use it to make up the train. Once the train is made up, a works order is passed to the crew.



Source: Avonwood

As the train leaves the yard, the tags on each wagon are scanned and a message is sent to the Amicus system to check that the train make-up agrees with the work order. The wagons are also weighed to check for load discrepancies and both sets of data are transmitted to the next stop, so that customers can be advised of arrival and staff can be allocated for unloading the wagons.

2.3.10. General Motors, USA - containers

Company	Application
General Motors (GM) USA	Land and sea logistics
Benefits Sought	**Status**
Cost reduction	Rolled out
Tag Frequency: Multiple frequencies Format: Read Only Active and passive tags	

Report
General Motors are developing a wireless radio system in order to track containers in car production plants. The system being trialled combines Wifi readers and PDA's and radio frequency tags, enabling real time location systems (RTLS).
Larry Graham of General Motors said the system would be focussed initially on the following warehousing areas:
Material Management.
Vehicle Inventory Management.
OSHA Driver Verification.
Rack and Inventory Management.
In-Line Vehicle Process Tracking.
Future benefits were cited as:
Wireless Diagnostics.
Automated Dealer Audits.
eGM Applications.
A schematic of the system is shown in figure 1.
General Motors are working with other automotive manufacturers but also across industry sectors to advance standards for such real time location systems; for example, Boeing, Caterpillar, The US Navy and The Department of Defense (DOD) are also involved.

2.3.11. Shanghai Railway, China

Benefits: Safety, efficiency
Status: Order Mar 15 2004
Payback: 1-2 years*
Tag supplier: TagMaster
Format: Large active heavy duty tags
Frequency: 2.45 GHz
Range: 10 meters
Price: $30*
Number: thousands
Interrogator supplier: TagMaster
Price: $3000
Number: 980
System integrator: TagMaster
Website: www.tagmaster.se
*IDTechEx estimate

2.3.12. Hamburg Metro Germany

Benefits: Safety, efficiency
Status: Rolled out
Payback: 1-2 years*
Tag supplier: TagMaster
Format: Large active heavy duty tags
Frequency: 2.45 GHz
Range: 10 meters
Price: $30*
Number: 800
Interrogator supplier: TagMaster
Price: $3000
Number: 190
System integrator: TagMaster
Website: www.tagmaster.se
*IDTechEx estimate

2.3.13. Parking, Arizona State University, USA

Status: Rolled out
Payback: 2 years*
Tag supplier: TagMaster
Format: vehicle windshield tag
Frequency: 2.45 GHz
Range: several meters
Number:18,000
Price :about $20*
Interrogator supplier: TagMaster
System integrator: TagMaster
Website: www.tagmaster.com
Utilises S1501/02 PassMan readers and S1255 MarkTags with ten year service time.
Benefits sought:
Convenient: hands-free, non-stop, VIP
Secure: unique and protected id
Fast: high throughput, no queues
Easy: no site licence required, plug'n play
Inexpensive: low maintenance & operating cost
Status: Rolled out
Payback: 2 years*
Tag supplier: TagMaster
Format: windshield active tag read only
Frequency: 2.45 GHz
Range: several meters
Price: $20*
Interrogator supplier: TagMaster
Number: 25
System integrator: TagMaster
*IDTechEx estimate

2.3.14. Korea World Cup vehicles

Company World Cup 2002 Korea	Application Passenger transport
Benefits Sought Speed, security	Status Roll–out (Complete) Start: 2002
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only	System Interrogator: TagMaster
Further Information TagMaster: www.tagmaster.com	

Report
Korea's Incheon Stadium implemented an RFID system during the World Cup in 2002 in order to provide fast and easy access to parking facilities for staff and regular visitors to the stadium.

Press release from May 2002 © TagMaster:

The Incheon Stadium in Korea, which will host many of the games in the Football World Cup 2002, has chosen TagMaster's longrange RFID vehicle identification system. The leading Korean parking specialist, MISCO, has installed the TagMaster system, which forms part of the parking control equipment. The TagMaster automatic identification system ensures that staff and regular visitors will be given fast, hands-free access to parking areas within the stadium complex. Six TagMaster readers have been mounted at selected entrance and exit lanes to provide fast-track access, 24 hours a day. Mr. Bongchoon Yoon, the manager of the stadium, needed a convenient system that allows fast vehicle access in all weathers. The complete MISCO installation at the stadium serves 4000 parking spaces and includes a total of 12 entrance lanes, 12 exit lanes and 6 automatic pay stations.

The Incheon stadium is located some thirty kilometres west of Seoul in the seaport city of Incheon, not far from the new international airport. With its seating capacity of 50,256 people, it will host World Cup matches for the teams from Portugal, Korea, Denmark, France, Costa Rica and Turkey. The Incheon Munhak Stadium's unique design is based upon the theme of a sailboat and represents the city's history as a major port and centre of international trade. The roof symbolises the sail and mast of a ship.

MISCO have represented TagMaster in Korea for several years and have completed a large number of installations around the country. MISCO manufacture the ParkMan series of automatic parking control equipment, for which TagMaster supplies the long-range identification system equipment.

2.4. Case studies of active RFID in the air industry

2.4.1. Sepang Airport, Malaysia – catering trolleys

Company Sepang Airport Malaysia	Application Airlines and airports
Benefits Sought System automation, Traceability	Status Roll–out (Complete)
Tag Supplier: Avonwood Frequency: LF (132 KHz) Format: Active Read/Write Label Range: 65cm	Interrogator: Avonwood System Integrator: Cegelec AEG
Further Information Avonwood: www.avonwood.co.uk	

Report
Malaysia's Sepang Airport in Kuala Lumpur handles around 35,000 in-flight meals daily and is using an RFID-based system to track and manage hundreds of catering trolleys. The system, installed by Cegelec AEG, uses the Eureka 311 RFID system provided by Avonwood and comprises 700 read-only active tags and 135 antennas, which transmit data to the Cegelec Realm IFC software.

When a flight arrives at the airport, the catering trolleys are unloaded from it and returned to the catering centre where they are loaded, by equipment "coat hangers" that carry two or four trolleys, onto a conveyor system. Each of the hangers is fitted with a Eureka 311 tag, which holds unique identity details. The tag is interrogated throughout the conveyor system, enabling the trolleys to be traced.

The operator at a control station then identifies the types of trolley and their content for the control system, which automatically routes hangers to either meal, bar or kit stripping stations. Once empty, the trolleys are again automatically routed to an automatic trolley washer before storage in large buffer areas ready for replenishment.

For outbound flights, the system automatically provides the airlines with the relevant trolleys made ready for return to the aircraft.

2.4.2. Los Angeles International Airport/ Long Beach, USA – vehicle tolling and management

Company Los Angeles International Airport ETTM USA	Application Passenger transport
Benefits Sought Faster throughput Practicality	Status Roll–out (Complete)
Tag Supplier: TransCore etc Format: Passive and active tags	Interrogator: TransCore etc System Integrator: TransCore etc

Figure 1 TransCore system in action

Source: TransCore

Report
Monthly revenue of the Los Angeles International Airport General Traffic Management System (GTMS) started at $250,000 per month, Globally, such electronic tolling and traffic management (ETTM) includes electronic non-stop tolling where 15 - 20 million vehicles now have RFID tags fitted to them worldwide.
Company profile : TransCore
The US company TransCore is world number one in Electronic Tolling and Traffic Management (ETTM). This term refers to systems for electronic tolling and traffic management using devices in vehicles. TransCore is also a leader in tagging rail freight and rolling stock. Its key activities are:
Mobile payment
Freight and fleet management
Intelligent transportation.
TransCore has 2,000 employees and has been in the transportation business for 60 years. Annual revenue exceeds $340 million and the order book is over $650 million largely thanks to long-term support contracts for non-stop road tolling schemes across the world. It acquired Amtech, leader in non-stop road tolling, in 2000.

The main RFID tracking applications:
Toll collection systems.
Transaction processing systems.
Rail tracking systems.
Parking and access control systems.
It has over 4,000 tolling lanes worldwide and is the largest integrator of third party hardware. In the US it has 61 per cent of installed lanes and they do 71 per cent of daily Automatic Vehicle Identification (AVI) transactions.
Worldwide, TransCore systems did 2.6 million tag-based transactions daily in 2001 with 22 toll customer service centres and 13 violation processing centres supported by the company.
Their tag characteristics are:
Multiple frequencies

- 915 MHz, 2,450 MHz.
Harsh environments
- Long service life (no/low maintenance
- High levels of shock and vibration.
- (40(to + 185(F operating temperatures.
Highly accurate and reliable (99.7 per cent+).
High speed (100 mph +).
Extended ranges (40 ft +).
Tag/reader selection critical for success.
TransCore's history of achievements includes:
1984 Invented RFID for toll applications.
1989 First 100 per cent implementation of ETC across multiple lanes.
1989 First congestion pricing system at airports.
1991 American Association of Railroads (AAR) mandates Amtech's RF tags as standard.
1991 First successful open-road tolling installation in the United States. (See illustration on previous page where interrogators look down from bridge).
1995 ISO chooses Amtech technology as standard for automatic identification of freight containers.
1998 World's first automated congestion pricing lane with automatic variable pricing.
1999 First tag transaction clearinghouse linking airports, toll roads, and parking garages.
2000 Introduced the revolutionary Intellitag, a paper-thin windshield sticker communications tag.
2000 World's first electronic registration tag.

2.4.3. Tacoma/ Seattle International Airport, USA – vehicle tolling and management

and

2.4.4. New York Newark International Airport, USA – vehicle tolling and management

Company Newark Liberty International Airport USA	Application Airlines and airports
Benefits Sought Crime prevention, Speed, Improved data capture	Status Trial successfully completed
Tag Supplier: ID Systems Frequency: UHF (UHF) Format: Passive Read/Write Label Vehicle tag Range: Several meters Price: Several dollars Number of Tags: Thousands	Interrogator: ID Systems System Integrator: ID Systems
Further Information: ID Systems: www.id-systems.com	

Report
ID Systems' RFID system for vehicle security and fleet management, the Wireless Asset Net, has passed a series of tests conducted at Newark Liberty International Airport by the USA FAA and TSA in 2004.

Effectiveness confirmed

The objective of the tests was to confirm the effectiveness of the RFID technology. ID Systems added advanced security capabilities to its core wireless vehicle management technology. This means that the new system can thwart potential threats, meeting TSA's objectives for monitoring vehicles that operate airside at commercial airports.

More specifically, the FAA/TSA wanted to demonstrate whether the Wireless Asset Net could provide:
effective reliable wireless communications in the airport environment (which already has a lot of RF emission)
enough security features to prevent unauthorised access to Port Authority of New York and New Jersey vehicles
a safe, user-friendly interface for authorised vehicle operators
automatic operator log-off from vehicles, based on software-configurable parameters
warnings when vehicles enter prohibited areas, including remote shutdown where necessary
operator alerts based on GPS activity
emergency disabling of vehicle access
reports on vehicle and/or operator activity, location, status, movement history, zone violations, unauthorised access attempts and other data
Variety of vehicles

The Wireless Asset Net system will be used for a cross-section of vehicles at the Newark International. Micro-computers called VACs will be mounted to the vehicles and will communicate bi-directionally with strategically-positioned gateways around the airport. These gateways will be linked to the ID Systems software on a local computer network and a central system security administrator will have access, and be able to respond, to vehicle data reported by the system.

2.4.5. Orange County Airport, USA – vehicle tolling

Company Los Angeles and Orange County Airports road tolling USA	Application Airlines and airports
Benefits Sought Reduced congestion Extra income	Status Roll–out (Complete)
Tag Supplier: Intermec Frequency: UHF (UHF (near 900 MHz) or 2.45 GHz) Format: Read Only	Interrogator: TransCore System Integrator: TransCore
Further Information Intermec: www.intermec.com TransCore: www.transcore.com	

Report
Many major airports across the world charge hotel and car park vehicles a modest annual fee for access to the airport. They now seek to extend the principle. Melbourne Airport, Australia wanted to charge commercial vehicles for access to the airport but a court forbade it, saying that aircraft handling fees covered this. By contrast, at airports such as Boston Logan International, USA, commercial vehicles are radio tagged using RFID technology. It is thus possible to charge them according to the time spent in the airport or the number of circuits made of the airport and this is legal. One reason for doing this is that some vehicles circuit airports simply to display advertising on their sides. Other vehicles are frequent users for other reasons, yet road space in most airports is a precious, limited commodity. This, then, is a form of "road pricing" that can develop into different charge rates according to time of day or congestion. As an indication of what we

may come to we can observe three generations of road pricing equipment in cities:
1) Passive (no battery) RFID device such as something like a thick credit card in the vehicle window. This simply identifies the vehicle. Charges are deducted from a customer account under computer control. The user has difficulty in proving they did not incur the charge.
2) Active (with battery) transponder. Works at longer distance. Stores its own record of transactions that can be used in evidence in the event of dispute.
3) Smart-card-operated transponder with display as can be seen in Singapore city. The card may be used for other functions such as parking.
Meanwhile, trip fees at some US airports such as Los Angeles and Orange County increase profits by 0.5 to 3 million dollars yearly, payback being only 1 - 2 years. The same technology can automate parking and control of taxis. System integrator Intermec report that most electronic road pricing schemes they encounter at airports pay back in less than one year. Examples of schemes using their equipment are:
John Wayne - GTMS
Installed: 1992
Size: 5 readers; 6,000 tags
Cost: $150,000
ROI: 7 months
Monthly revenue: $38,000
Los Angeles - GTMS
Installed: 1990
Size: 51 readers; 18,000 tags
Cost: $1.2 million
ROI: 11 months
Monthly revenue: $250,000

2.4.6. Hong Kong International Airport, China – catering trolleys

Company Hong Kong International Airport Hong Kong	Application Airlines and airports
Benefits Sought	Status
Tag Supplier: Avonwood Frequency: UHF (433 MHz)	Interrogator: Avonwood System Integrator: Cegelec AEG
Format: Active Read/Write	
Further Information Avonwood: www.avonwood.co.uk	

Report
Hong Kong International Airport, China, is using an automated in-flight catering system to handle 55,000 meals for 38 airlines every day. The system, installed by Cegelec AEG, uses the Eureka 311 RFID system of Avonwood Developments, UK and comprises 700 read-only active tags and 135 antennas, which transmit data to the Cegelec Realm IFC software.
On each flight's arrival, all catering trolleys are unloaded and returned to the catering centre, then loaded onto a conveyor system. Equipment "coathangers" that typically carry two or four trolleys, depending on size. Each hanger contains a tag, carrying the customer code and serial number, used by the antennas, which activate and receive data from the tags.
At the control stations, operators identify the types of trolley and their contents and input these data into the control systems, which plan where the hangers have to go, for example, to meal-, bar- or kit-stripping stations, where the trolleys are emptied of waste. Empty trolleys are routed to the automatic trolley washer and stored in buffer areas prior to replenishment.

2.4.7. Vienna International Airport, Austria – ground support equipment

Company Ground Support Equipment (GSE) USA, Austria	Application Airlines and airports
Benefits Sought Efficiency Security	Status Rolled out
Tag Supplier: Axcess, IBM Frequency: UHF (near 900 MHz) Format: Active Read Only Price: $30.00	

Report
Ground support equipment (GSE) is the vehicles allowed on the apron at airports to tow aircraft, fetch and carry fluids and so on. It must be secure and preferably its location and status (e.g. battery charge, next usage intended) known at all times. IBM with SITA, the airport software and system integrator trialled RFID for this purpose at Vienna International Airport but IBM subsequently left the RFID hardware business. Others continue the work, including RFID supplier Axcess.

2.4.8. Charles de Gaulle international Airport, France – taxis

Company Charles de Gaulle Airport taxis France	Application Airlines and airports
Benefits Sought Reduced pollution Improved security Reduced congestion	Status
Tag Supplier: Balogh Group Format: Active Read/Write	Interrogator: Balogh Group System Integrator: Balogh Group

Report
Charles de Gaulle International Airport in France has regulated taxi flow with RFID since August 2001.
15,000 Parisian taxis re identified by the Balogh Group' long distance HYPERX Identification products.
All authorised taxis arrive in a special reserved zone away from the terminals. They are called for as passengers' flights arrive. The taxi park zone is controlled, accounting for incoming and outgoing taxis.
Pirate taxis working without legal licences have been totally eliminated by the installation of RFID. Air pollution has been reduced. When the taxis arrive in their newly allocated zone, they can stop their engines while waiting to be called to the passenger pick up points. Paris Airports have been able to reuse their space around the airport terminals and reinforce

their security.
HYPERX Semi-passive badges are positioned inside the overhead taxi sign on top of each taxi. Identification takes place even at high speed and from a distance of several metres.

2.4.9. Envirotainer, Belgium – unit load devices

Company Envirotainer air cargo Europe	Application Airlines and airports
Benefits Sought	Status Rolled out
Tag Supplier: Savi Technology Frequency: UHF (433 MHz)	Interrogator: Savi Technology System Integrator: Savi Technology
Format: Active	
Read/Write	
Price: $30.00	
Further Information Savi Technology: www.savi.com	

Report
In a typical air cargo operation, boxes and items are consolidated into Unit Load Devices (ULDs), which in turn are loaded into the belly of an aircraft. The boxes and items only need to be separately tracked up to the point at which they are loaded into the ULD. Once loaded and manifested, the location and status of the items can be determined by tracking the associated ULD. Since the loading process is usually structured and orderly, with dedicated loading stations and conveyors, Passive RFID is often sufficient and most cost-effective for tracking the individual items and boxes. The ULDs, however, present different tracking requirements. They move throughout large air terminals and tarmac areas, requiring area-monitoring capabilities to locate specific ULDs for loading onto aircraft. These are also significant security concerns, driving requirements for sophisticated sealing and security monitoring capabilities a loaded and empty ULDs are moved through the airport facility and loaded onto aircraft. All of these requirements lead to the need for Active RFID technology for the ULD. See table 1.

Table 1 Typical RFID requirements for air cargo

Item	Characteristics	Technology
Boxes Individual items Luggage	Structured, orderly process for loading - dedicated loading stations, conveyors.	Passive RFID Barcode
ULD (Unit Load Device)	Unstructured movement throughout airport facility (unstructured). Security requirements	Active RFID

Source: Savi Technology
Envirotainer AB, the world leader in providing temperature controlled air cargo solutions for sensitive products, has selected Savi Technology to extend the functionality and capabilities of its existing information system by deploying Savi's software platform and asset management and security software applications. The complementary solution will serve as the foundation for the first real-time information sharing network in the $8 billion marketplace for temperature-sensitive air cargo. Savi Technology's real-time solution will help Envirotainer to improve the management, security and visibility of temperature controlled air cargo Unit Load Devices (ULDs) and the highly sensitive goods they transport worldwide, such as pharmaceuticals, seafood, meat, produce and semiconductors.
The initial phase of the ULD management network enables Envirotainer to become more competitive and efficient with better-quality and real-time information on the status, location, condition, security and performance of the temperature-

controlled ULDs, which it manufactures and leases to air freight carriers, logistics service providers and shippers (manufacturers and distributors). Envirotainer owns and operates close to 3,000 highly sophisticated temperature-controlled ULDs, providing operational services at more than 120 international airports over 35 countries. The Envirotainer solution allows Pharmaceuticals and Perishables to be kept at carefully controlled stable temperatures throughout the supply chain.
The Savi Asset Management System™ (AMS) software application and Savi Supply Chain Logistics Portal™ enable Envirotainer to leverage the Internet to electronically pool and re-consign its ULDs from multiple airlines and locations, enhancing operational efficiency, asset utilization and customer service while knowing the integrity of contents, which can be damaged or ruined if the cool temperatures or sterile environments of the ULDs are compromised. In addition, Envirotainer's customers will be able to go online to book ULDs, track their movements and the security of their contents, monitor temperature history and review shipping patterns.
"We examined a number of best-of-breed providers of electronic tracking and asset management systems and selected Savi Technology because of the maturity and reliability of their innovative technology, ability to scale their product worldwide and unique capabilities to manage the full life cycle of supply chain assets", said Bernhard Metzger, Executive Vice President of Envirotainer AB.
"By using our full complement of software solutions, Envirotainer and its customers gain useful and timely information to ensure that the right ULD gets to the right location, boards the right aircraft at the right time, and then gets the product to the end customer safely at the right time and temperature", said Bruce Jacquemard, Savi's Executive Vice President and General Manager of Global Field Operations. "We look forward to working with Envirotainer to enhance services for what's already the pre-eminent leader in the fastest growing segment of the air cargo market - temperature-sensitive products".
Savi's software and collaboration portal include ULD acquisition features, financial and demurrage information, planning capabilities, billing status, flight details, updates on storage and maintenance schedules and performance analytics.
The Envirotainer modular software roll out, scheduled between fall of 2002 and spring of 2003, is the first of an anticipated multi-phased project, which also includes implementation of the extensible Savi SmartChain™ software platform and Savi's Universal Data Appliance Protocol (UDAP), which is an open interface that translates data transmitted by all types of hardware data collection devices to the SmartChain platform. Both the SmartChain platform and UDAP will wet the foundation for the next planned phase in mid-2003 : affixing automatic data collection technologies, such as Radio Frequency Identification (RFID) tags, electronic security seals, or Global Positioning System (GPS) devices onto ULDs, and then integrating data transmitted from them with Savi's AMS software, creating an interlinked hardware/software combination that will provide yet another new dimension of real-time visibility and management.
Transportation of temperature sensitive goods is becoming fiercely competitive in a global marketplace where there are increasingly stringent government regulations for these kinds of products, and growing concerns about the freshness or health of products such as food that can become easily infected by bacteria with minor changes in temperature.
Air cargo is increasingly employing RFID for efficiency and against the new terrorism. For example SCS are developing readers to go around the freight doors on aircraft and they fit their 2.45 GHz tags on freight.

2.4.10. Air Canada - food trolleys

Company	Application
Air Canada Canada	Airlines and airports
Benefits Sought	**Status**
Cost reduction, Inventory control	Roll–out (Complete)
Tag **Frequency:**	**System Integrator:** ScanPak
UHF (433 MHz)	
Format: Active	

Report
Air Canada found that it was losing millions of dollars annually in catering, maintenance and warehouse trolley costs. Even after it had conducted a global search for its trolleys, it found there were still $2 million worth of unexplained losses. The company decided to implement an RFID-based system to improve the method of tracking and tracing its 10,000 trolleys across 50 locations around the world.

Air Canada chose Scanpak's Galley Equipment Tracking System (GETS) to keep track of its trolleys. The system uses 433.92 MHz tags on each trolley to ensure they can be tracked at all times.

Benefits
On implementation of the system, the company saw the following improvements:
80% reduction in trolley losses
2% reduction in total trolley inventory, as they did not have to purchase extra trolleys in anticipation of losses
20-50% reduction in trolley trucking charges
5% reduction in trolley maintenance costs
100% reduction in stocktaking costs
dramatic improvements in asset utilisation
Elimination of unavailable trolleys as a cause of flight delays
Accurate trend information for improved planning

2.4.11. Arlanda International Airport, Sweden parking

Benefits sought: Convenient: hands-free, non-stop, VIP
Secure: unique and protected id
Fast: high throughput, no queues
Easy: no site licence required, plug'n play
Inexpensive: low maintenance & operating cost
Status: Rolled out
Payback: 2 years*
Tag supplier: TagMaster
Format: windshield active tag read only
Frequency: 2.45 GHz
Range: several meters
Price: $20*
Interrogator supplier: TagMaster
Number: 25
System integrator: TagMaster
High speed access control helping 9,000 employee vehicles and shuttle-buses smoothly to and from the airport's parking lot, utilising 10 lanes. Implemented and supported by Peek Traffic. The installations utilises S1500 WiseMan readers and S1255 MarkTags with ten year service time
*IDTechEx estimate

2.5. Case studies of active RFID in healthcare

2.5.1. Massachusetts General Hospital, USA people and assets

Company Massachusetts General Hospital USA	Application Healthcare
Benefits Sought Error prevention, cost reduction, customer service	Status Trial (Ongoing) Payback: 1-2 years (Radianse estimate)
Tag Supplier: Radianse Format: Active pendants, key fobs etc with GPS Range: many meters	Interrogator: Radianse System Integrator: Radianse Project Cost: £500-2000 per bed
Further Information Radianse: www.radianse.com	

Report
Radianse Inc., a startup that helps health care organizations track people and equipment, has raised $9 million in private venture financing. Radianse was initially founded as Sentinel Wireless Inc. in November 2000 by former managers from Hewlett-Packard Co. and Philips Medical Systems. HLM Venture Partners of Boston and Partech International of San Francisco each pledged $3.25 million to the round. Ascension Health Ventures, a subsidiary of the Catholic health ministry Ascension Health, pledged $2.5 million.

The Lawrence, Massachusetts.-based company has tags which combine radio-frequency identification technology with what it calls an indoor version of the Global Positioning System. Contrast ELPAS Israel which does a similar task in healthcare with a combination of active RFID and infrared ID sensing. Traditional GPS does not work indoors but new types, such as those using the technology patented by Qinetiq in the UK, can be several thousand times more sensitive and work in some buildings and "urban canyons" like Manhattan.

Matt Hermann, director of Strategic Health Venture Investing for Ascension Health Ventures, said many hospitals thought the technology could cut costs and streamline workflow.

"During our diligence, several Ascension Health hospitals expressed an interest in Radianse and its unique approach to indoor positioning. The Radianse approach breaks through the barriers of cost and accuracy that have plagued other location technologies," he said in a written statement.
Radianse says that its systems cost from $500 to $2000 per bed, depending on the coverage area and the number of items and people tagged. According to the company, the systems will pay for themselves between one and two years.

A Radianse system has already been installed at Boston's Massachusetts General Hospital as part of a program for innovative care. The systems rely on small, battery-powered i.e. active ID tags that are attached to equipment, worn by people, or integrated into other assets. Each tag transmits a unique identifier. Two buttons on the tag allow personnel to transmit information about patients' and equipment's status. We believe that this is not available with competitive systems from Elpas of Israel, Bluetag of Denmark etc.

Radianse receivers work by connecting into a hospital's existing LAN network. Information is conveyed using common Web and interface standards such as XML and SMS, as well as Java and ODBC. The system is intended to prevent patient misidentification, to ensure that patients are in their rooms or ready for a procedure during doctor rounds, increase patient throughput for various clinical procedures and reduce the labour costs by quickly identifying where people and equipment are situated. The system can track patient wait times and equipment use, all this adding up to an unprecedented level of functionality for an RFID based healthcare system.

2.5.2. Other US hospitals – asset tracking

Company Various US Hospitals USA	Application Healthcare
Benefits Sought Crime prevention	Status End: Feb 2004
Tag Format: Active Read/Write Label	System Integrator: eXI Systems

Report
eXI Systems is a subsidiary of Canadian company eXI Wireless Inc, which provides RFID-based asset management and security solutions. In February 2004, the company announced that it had completed an RFID asset tag trial programme with 22 hospitals in the US.

The trial demonstrated Assetrac, a single system for protecting, locating and tracking hospital equipment. Assetrac works concurrently with eXI's HALO infant protection solution, which prevents infant abductions, and can provide significant cost savings. It has been reported that the theft of equipment and supplies costs hospitals an estimated $4000 per bed each year. With more than 975,000 staffed beds in the US, this represents a potential loss of $3.9 billion annually, the financial burden of which ultimately falls on the facility.

Under the Assetrac system, tamperproof "Asset Tags" are fixed to medical equipment and send a signal to interrogators in the facility and an alarm will sound if an unauthorised attempt to exit the secure perimeter is made. The tag will also alert the system if it is removed from the item. The system also has a graphical interface that includes the facility's floor plan and can direct staff to the vicinity of the asset they are looking for.

There are two different streams to the Assetrac system:

· ProtecPoint, which protects high value assets from loss by providing an individual, secure zone around doors where only an authorised personnel can transport tagged assets without triggering an alarm.

· Assetrac Control 4.0, which can be used to manage assets as well as tracking them, creating custom reports for scheduled maintenance, asset utilisation or inventory control.

2.5.3. Hospitals, Israel and elsewhere – patient and staff tracking/ alert

Company Staff and patient identity and location Israel	Application Healthcare
Benefits Sought Cost reduction Safety	Status Roll–out (Complete)
Tag Supplier: ELPAS Format: Passive tag - read/write; Active tag - read only	Interrogator: ELPAS System Integrator: Ascom Honeywell ELPAS
Further Information: ELPAS: www.elpas.com	

Figure 1 EIRIS Technology IRFIDTM Components

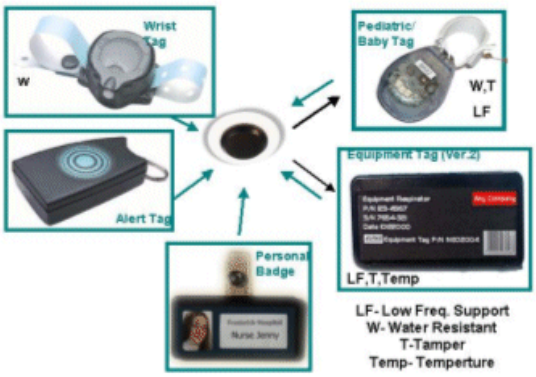
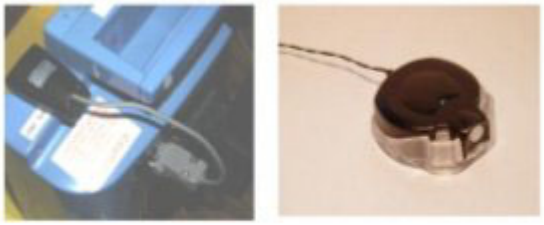


Figure 2 EIRIS Technology Tags

Figure 3 EIRIS Technology : Who, What, Where and When? - WWWW™



Data Collecting Tag Attached to IVAC

Equipment Tag with sensor input

Figure 4 EIRIS System Architecture

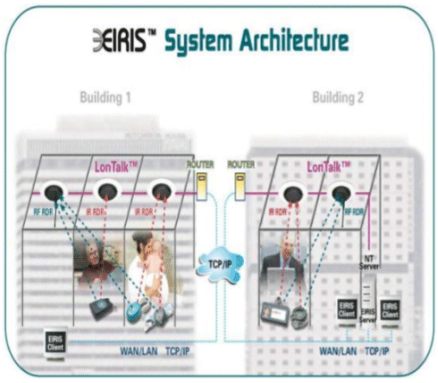


Figure 5 EIRIS Technology Optimal Installation

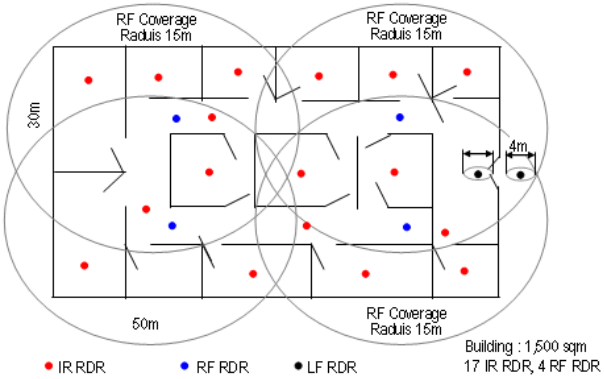


Figure 6 ELPAS' System Architecture

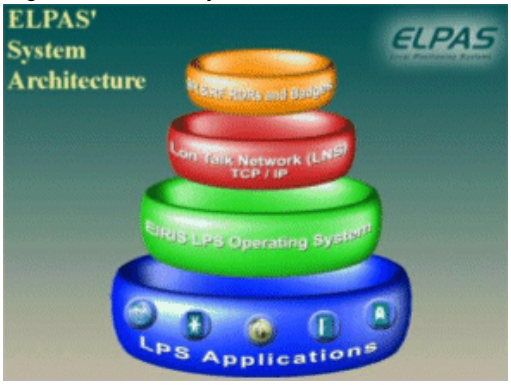


Figure 7 ELPAS' Healthcare Applications

All figures source: ELPAS

Report
EIRIS of Israel has one of the most sophisticated staff badge systems. For example, it can even be arranged that telephone calls for staff are routed to the nearest telephone to them wherever they go.
It does not come cheaply. These tags cost $50-100 each and an even larger component of cost can be the infrastructure of readers "talking to" central computer systems. However, the tags are reusable and these systems have been installed in about 500 hospitals to date. That involves tens of thousands of tags and Ofer Youvexel, executive vice president, tells us that using a standard ASIC chip would be justified at higher volume and millions of tags could be sold at only $10 or so each.
To support such major systems, EIRIS has an alliance with Honeywell, which has its WWWW™ intelligent building system dedicated to Who What Where and When? (Thanks to the computer system we might add that it can often also say Why?) This is part of Honeywell's "Enterprise Building Integrator" product. EIRIS is also allied to Nissho Iwai for sales and support in Japan, to Siemens Medical for integration into Siemens Medical Telemetry business and with Ascom for integration into Ascom LAN based Nurse Call System.
Unusually, the technology is based on infrared sensing as well as RFID at two frequencies. This is claimed to achieve the best of all worlds.
The battery driven "active" RFID function gives:
Long range - from several centimetres to hundreds of meters.
Constant communication.
Real time location.
Data collection and dissemination capabilities.
At UHF, there is constant communication even when covered but the LF function gives good automated exit coverage in the view of the company.
The infrared function gives exact and cost effective location in rooms.
The main components involved are shown in figure 1
The main features of the EIRIS tags (shown in figure 2) include:
On-board motion detector.
Triple technology.
Field programmable characteristics (about 50 different character flash memory on-board).
Variety of features such as buttons, tamper, temperature, digital inputs.
Crystal controlled narrow band UHF transmission.
The tags, as in figure 3, may even have sensors for data collection where it can interrogate an asset (via a RS232 or other protocol) for its environmental/operational conditions and transfer up to 26 bytes of information like:
Utilisation
Temperature
The system architecture is shown in figures 4, 5 and 6 and the applications as shown in figure 7
Case profile : Ascom, Switzerland
Communications company Ascom (Bern, Switzerland) and ELPAS Local Positioning Systems (Ra'anana, Israel) announced a strategic partnership agreement in 2001. The ELPAS's EIRIS local positioning system (LPS) will be integrated into Ascom's healthcare products, to enable real-time location and identification of patients, staff and critical assets within the healthcare environment. This is the same system as used by Honeywell.
Real time monitoring
EIRIS LPS, which is now integrated into Ascom's products and systems, uses its IRFID (infrared and radio-frequency identification) technology to transmit ongoing location in real-time.
Patients, staff and equipment are assigned small IRFID tags that send signals to ceiling-mounted readers, that transfer the data to a central server. An open architecture design allows for seamless integration with other healthcare operation systems, facility automation and security devices.
The location or tagging information, which is gathered by the EIRIS system, is presented in the Ascom nurse-call system TeleCARE™ through pagers and cordless telephones. The integrated solution enables staff to be aware of a tag bearer's location without being confined to the nurse station.
Dahn Jubell, Business Manager of the Healthcare Segment at Ascom Enterprise Communications says that an important criterion for the decision was that the LPS was an open architecture system, so it could be easily integrated into existing systems.

2.5.4. Shelby County Regional Medical Center, USA – patient tracking

Company Shelby County Regional Medical Center USA	Application Healthcare
Benefits Sought Improved data capture, Error prevention, Traceability	Status Trial successfully completed Start: Jan 2004 End: Apr 2004
Tag Supplier: Alien Technology Frequency: Microwave (2.45 GHz) Format: Active Read Only Label Range: 30m	Interrogator: Alien Technology
Further Information Alien Technology: www.alientechnology.com	

Report

The Trauma Emergency Department at the Shelby County Regional Medical Center in Memphis USA sees an average of 60 patients a day. RFID technology has been trialled in the Department, to track patients as they move through trauma care, determining how long they were at each location in the hospital.

The RFID implementation was designed and installed by Idensys, as system integrator, using Alien Technology's 2.45GHz battery-powered system.

Each of 5,000 patients tracked during the three-month trial had an adhesive-backed RFID tag stuck to their ankle on entering the trauma center. To dispel fears about privacy, patients were informed of the purpose and nature of the trial, and only the tag's unique ID code was recorded by the system, rather than any patient or injury details.

Twenty-five RFID interrogators were installed at various locations throughout the approximately 250,000-square-foot facility, including in three X-ray rooms, two CAT scan rooms, two intensive-care units, an operating room and several general areas. Only the MRI (magnetic resonance imaging) scan room was not covered, since the effects of RFID on MRI equipment is not known.

An interrogator would read each tag within its range between 4 and 50 times per minute and transmit data over a LAN to a central SQL database running on a PC in the hospital's data center. The database retained only the first and last read taken of each tag, so that a patient's location could be mapped at all times.

The next phase of the project will be to determine whether the pilot should be extended to cover other sections of the Shelby County Regional Medical Center or trauma centers in other parts of the United States. The system at the Shelby County trauma center continues to track and collect data on patient locations, though as yet the Center has not decided on how it will use that data to improve the its processes and services.

2.5.5. Royal Sussex County Hospital, UK – assets

Company Royal Sussex County Hospital assets UK	Application Healthcare
Benefits Sought Error reduction Rapid audit Cost reduction Crime reduction	Status
Tag Supplier: Avonwood Frequency: LF (125 – 135 KHz) Format: Active Read/Write	Interrogator: Avonwood System Integrator: Avonwood
Further Information Avonwood: www.avonwood.co.uk	

Report

The Royal Sussex County Hospital in Brighton, UK realised its manual paper-based system for recording the collection and return of devices from the equipment library room was highly inefficient. An RFID access control system helped to improve the situation but staff soon realised that this could be further enhanced by using RFID to track the assets, to eliminate human error with the paper-based system.

As a result of the consistently high read rate achieved, the hospital's management has decided to extend the system to hundreds of other portable assets across the site.

The new system accurately logs items in and out of the equipment library room without staff having to fill in a form. It fully integrates with the hospital's asset management system and permits the addition of an LED display, as well as a PC based graphical user interface GUI to display the number of tagged items being logged in or out.

From the outset it was clear that a passive solution would not work. The main challenges were (a) distance at which the tags would have to be read, (b) their orientation and (c) the number of tags in the RF field at any one time. Although the tags met these requirements, bespoke antenna still had to be designed and a plastic, rather than metal, trolley sourced to ensure RF performance.

The Royal Sussex County Hospital has shown a commitment to the UK government's initiative to use new technologies in the National Health Service NHS and are encouraging other hospitals to examine its benefits closely.

2.5.6. HCA Hospital Dallas, USA – mother baby matching

Company HCA Hospital Dallas USA	Application Healthcare
Benefits Sought Error reduction, Crime prevention	Status Roll–out (Complete)
Tag Supplier: Xmark Format: Active Read/Write Wristband Reusable 5 year life Price: $150 Number of Tags: A few dozen	Interrogator: Xmark Project Cost: $10-15K for a small system
Further Information Xmark: www.xmarksystems.com	

Report
10,000 healthcare facilities in the US have RFID wristbands for Alzheimer's patients and 1,000, including the HCA Hospital in Dallas, have them for preventing mother/baby mismatches. The largest of these hospitals deliver 15,000 babies yearly and may have at least 5,000 tags.

The system used at Dallas's HCA Hospital is called Kisses. Produced by Xmark, Kisses enables the accurate identification of mothers and children, ensuring that mothers and babies are correctly "matched". The tags for both mothers and children are worn on a wristband, and these can be integrated with a normal hospital identification wristband.

2.5.7. HCA Hospital Arlington, USA – mother baby matching

Company HCA Hospital Arlington USA	Application Healthcare
Benefits Sought Error reduction, Crime prevention	Status Roll–out (Complete)
Tag Supplier: Xmark Format: Active Wristband Price: $150	Interrogator: Xmark Project Cost: $10-25k for a small system
Further Information Xmark: www.xmarksystems.com	

Report
10,000 healthcare facilities in the US have RFID wristbands for Alzheimer's patients and 1,000, including HCA Hospital in Arlington, have them for preventing mother/baby mismatches. The largest of these hospitals deliver 15,000 babies yearly and may have at least 5,000 tags but HCA Hospital is initially using just 15.

The system used at Arlington's HCA Hospital is called Hugs (child tag) and Kisses (mother tag). Produced by Xmark, Kisses enables the accurate identification of mothers and children, ensuring that mothers and babies are correctly "matched". The tags for both mothers and children are worn on a wristband, and these can be integrated with a normal hospital identification wristband.

2.5.8. French Blood Agency, France – chemovigilance

Company	Application
French Blood Agency chemovigilance France	Healthcare
Benefits Sought	**Status**
Cost reduction Error reduction	
Tag	
Supplier: Technopuce Frequency: HF (13.56 MHz) Format: Active Read/Write Label	Interrogator: Technopuce System Integrator: Technopuce

Report
Technopuce is the French manufacturer of an active (battery in tag) line of RFID labels known as Acti-Tag™. While the overwhelming majority of tag manufacturers are looking to enhance their passive applications today, Technopuce has chosen to travel another road and devote its efforts to developing its patented active (tag with a battery) RFID technology.
Technopuce noted that, in blood transfusion:
Data relative to the collection, preparation, control and maintenance of the temperature as a function of time still was largely unsatisfactory.
Small, thin flexible tag on blood bag allows for the recording of a number of parameters.
Allows for continuous temperature monitoring, critical in controlling the quality of the product and the management of the cold chain.
Critical improvement in blood supply chain management can be obtained with RFID in:
Patient safety.
Supply management shortage prevention (especially of rare blood types).
Improved economics.
Acti-Tag™ offers a reliable and tamper-proof solution to these problems.
Technopuce's Acti-Tag™ uses active RFID technology to provide high reading speeds and long read ranges of up to 150 meters - operating at high-frequency ranges of 433 MHz or 868/915 MHz. The tag also makes use of transponder technology for short-range communications distances of up to 1 meter operating at frequencies of 125 KHz or 13.56 MHz.
The company has patented an innovative process that integrates a thin. flexible 3.6 Volt lithium/manganese oxide primary battery into the Acti-Tag™ radio frequency circuitry. This lithium/manganese oxide micro-battery on flex power source offers distinct advantages over other battery systems, the most significant of which are low self-discharge, high reliability, and high energy density. This Battery on Flex technology ensures the best tuning balance between microelectronics and electrochemistry, and gives Acti-Tag™ optimum response performance during periods of peak current requirements.
Sensors
Acti-Tag™ can also be equipped with a number of embedded sensors, which enable it to carry out real-time continuous monitoring of such critical parameters as temperature, vibrations, humidity, motion, and stress. At the time of writing, the

tag is being used in a number of applications involving the tracking of strategic assets. One such application involving cold chain management is currently being tested at France's largest blood transfusion center, where the tags are being used for the continuous monitoring of blood bag temperatures throughout the entire supply chain process. Since the global blood community demands a safe, available blood supply, it increasingly relies on new technologies to improve blood safety. Technopuce's technology allows blood banks to monitor in real-time the external temperature fluctuations that each blood bag undergoes, thereby greatly reducing the risk of administering blood that has been exposed to risk of contamination due to bacteria development in blood that has been improperly stored. Not only does this technology ensure patient safety, but it also provides the transfusion centers with improved blood supply management, allowing for the prevention of shortages or rarer blood types, as well as improvement of the economics of the transfusion process.
The RFID version for monitoring temperature-time behaviour of blood in transit and storage is called Hemo-Tag™ and it has won a number of awards. The company says, "Transfusion security is today at the heart of the preoccupations of the public authorities and health care professionals. A certain number of procedures have been put in place such as hemovigilance, which aims to reinforce the co-ordination of the actions of control in surveillance and sanitary alert, as well as a guide to transfusion practices in terms of transport destined to establish rules which guarantee the quality of the products transported, for example by imposing temperature indicators during their journey between the EFS (French Blood Agency) and the care centres".
Some 2,506,541 blood samples were taken in France in 2001 and Hemo-Tag™ is used to control the traceability of labile blood products by continuously recording the temperature in real-time during the transport, processing, conservation and product distribution phases.
Hemo-Tag™ is a single use tag that is placed on the blood bag. The Hemo-Tag™ label is equipped with a transponder and an antenna, an embedded energy source and a temperature sensor that records the temperature of the contents of the bag at regular intervals throughout its lifetime. In addition to more than 15,000 temperature measuring points, the microprocessor contained in the Hemo-Tag™ is capable of memorising all the information pertaining the donor, the product and the different processing and logistics phases. The contactless reading and data processing that uses dedicated equipment and software make it possible to control whether the cold chain has been complied with and if not, locates the precise moment and place where the break occurred. The traceability of labile blood products in terms of temperature is, as a result, perfectly controlled and thus contributes to reducing the transfusion risk. Table 1 gives the Hemo-Tag™ specifications.

Table 1 Hemo-Tag™ specifications

Parameter	Value
Size	Width : 54mm Length : 85.6mm
Thickness	‹ 1mm
Protected product	Password and single identification number
Operating frequency	Transponder mode: 13.56 MHz
Communication distance	Transponder mode: up to 10 centimeters
User memory	Non-volatile memory EEPROM 1K bytes
Temperature memory	Non-volatile memory EEPROM 15,000 measuring points
Sampling period	Configurable (1 minute to 10 hours)
Precision of the temperature measurements	From -10°C to +50°C +/- 1°C within a range of de 20°C
Surveillance	2 programmable alarm limits (high and low)
Storage temperature	From -20°C to +80°C
Material properties	Polymer moulding hermetic to humidity, external environment
Battery	Lithium / Manganese dioxide - 3.6 Volts
Lifetime	50 days for monitoring red cells concentrates.

Source: Technopuce

2.5.9. Alexandra Hospital, Singapore – people tracking for SARS

and

2.5.10. National University Hospital Singapore – people tracking for SARS

Company Alexandra and National University Hospitals Fighting SARS Singapore	Application Healthcare
Benefits Sought Safety	Status Trial (Ongoing)
Tag Supplier: ST Electronics (ST Engineering) Frequency: UHF (433 MHz)	Interrogator: ST Electronics (ST Engineering) System Integrator: Defense Science & Technology Agency
Format: Active Read/Write Card	

Report

RFID has a role in the global battle to contain Severe Acute Respiratory Syndrome, or SARS. Two hospitals in Singapore have an RFID system that tracks the movement of staff, visitors and patients so they can trace all of the people with whom a suspected SARS patient had contact.

"With this system, exact information on when a person enters or leaves a certain area is recorded automatically", announced Joshua Lee, program manager for the Defense Science & Technology Agency (DSTA), which developed the system. "When needed, information on the persons he could have been in contact with can be obtained quickly, using the search and query capability of the system".

From May 2003 Alexandra Hospital, the only public hospital in Singapore not to be touched by the SARS outbreak, tested the new Hospital Management Tracking System in its accident and emergency department. The National University Hospital started a trial for its staff in May 2003, and this was then extended to cover patients and visitors.

All patients, visitors and staff who enter areas in the two hospitals where the trials are being conducted must provide their name and contact information at the registration counter, so they can be contacted later if necessary. They are then given an active (with battery) RFID card.

Hospital employees have also been given these cards. The active devices continually transmit RFID signals at 433 MHz to readers placed around the facilities. The emergency department at Alexandra Hospital is divided into several zones. A receiver has been installed in the ceiling of each zone.

The SARS virus incubates in 10 days, so the system was set up to store information on visitors for 21 days. This ensured that information about all the contacts a probable SARS patient had within the hospital remains available well after the incubation period. The information, which is confidential, is deleted from the system after 21 days.

Singapore's DSTA developed the system after it received a request from the Ministry of Health to explore ways to trace contacts within a hospital should there be a suspected SARS case. DSTA evaluated various options, but quickly settled on RFID. Particularly attractive was its ability to track people without interrupting operations in the hospital or requiring staff to do significant additional work. The system was proved not to interfere with hospital equipment.

DSTA worked with ST Electronics, a unit of Singapore's ST Engineering. ST created the software that enables the system to track in real-time when a person enters or leaves a certain zone. It formulated back-end software that allows staff to query the database for information. Hospital staff access the application through a portal on the hospital's intranet. If a patient is suspected of having SARS, staff can run an immediate check to find out who has had contact with them, in which zone and at what time.
The system runs off the hospital's existing local area network. It was built with off-the-shelf RFID tags and readers. It can trace an unlimited number of people. However, each reader can only cope with 100 RFID cards at one time.
Initially, there were blind spots where the receivers failed to receive the RF signal emitted by the cards. "The engineers had to fine-tune the receivers' sensitivity to ensure adequate coverage for the entire emergency department", said Lee. "If the receivers were too sensitive, there would be an overlap in the coverage. And if they weren't sensitive enough, certain areas would not be covered".
Alexandra Hospital handles about 250 emergency cases a day, with each patient allowed one visitor. There are also 36 doctors and nurses working in the department and the system has adequately tracked the movements and contacts of more than 500 people per day. So far, there have been no SARS cases, so the system has not been needed to trace back contacts.

2.5.11. Hart District, UK – alarm for elderly

Company	Application
Hart District Council UK	Healthcare
Benefits Sought	**Status**
Independence and safety for the elderly and disabled	Roll–out (Complete)
Tag	
Supplier: Tunstall Telecom	Interrogator: Tunstall Telecom
Format: Active pendant - life of 5 years	Interrogator Price: Hundreds of dollars System Integrator: Tunstall Telecom
Range: 25 meters	
Price: Several dollars	
Number of Tags: Thousands	
Further Information	
Tunstall Telecom: www.tunstall.co.uk	

Report
These pendants are issued with a telephone auto dialler by the local government as a non-profit venture. If the alarm button on the pendant is pressed, a central manned exchange contacts helpers in prearranged order of priority to go to the house and help the pendant wearer.

2.6. Case studies of active RFID in the military sector

2.6.1. Kosovo/ US Military – military assets and supplies

Company USA	Application Military
Benefits Sought Cost reduction Speed	Status Roll–out (Complete)
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active	Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report
Betsy DeLong of the USA Military, opened the "Achieving Total Asset Visibility (TAV)" conference track by discussing their needs for RFID and item condition monitoring and their roadmap to realize TAV. Identification only is not enough for the military; although they want to achieve automated receipt and inventory processes they also wish to monitor item condition (such as temperature, humidity, shock etc.). This would enable them to create predictive models to determine the future shelf life of items.
Automatic Identification Technologies (AIT) are intended to be implemented throughout the Department of Defense (DoD), with trial implementations running this year and the implementation of commercial data standards expected in mid 2004. Of the possible AIT technologies, Delong highlights the intent to use RFID at each level of their supply chain, from conveyances to embedded RF tags and chips in multipacks and in items themselves. They have identified the paybacks that this level of automated source data will provide - both directly, and the less obvious to calculate but nonetheless important indirect benefits, such as reduced manpower and manual intervention, reduction of dangerous work and the ability to streamline processes.
Betsy described one of their most recent technology demonstrations, to continuously locate and monitor the condition of munitions, while also predicting their future condition and performance to a high degree of accuracy. Munitions degrade over time and temperature exposure, and currently tests to check the reliability and safety of munitions are done so destructively. The temperature conditions experienced by munitions vary across their life span their performance reliability can be accurately predicted. They have therefore combined an active RFID tag (battery assisted), offering a 300 feet read range, with sensor arrays tailored for each weapon system and used these at the pallet/container level. A combination of fixed storage readers and handheld readers enable near real time surveillance and inventory updates through a long range communications link to a central nerve center. The system immediately flags up if condition thresholds are breached and store a temperature history log of the munitions.
Betsy also highlighted the DoD's other goals such as enabling inside-the-box visibility by installing RFID readers in large munitions containers which identify all the items in the container and radio the inventory and condition information to satellites.
The information could then be read anywhere in the world by a network of 66 satellites. Over $200 million has been invested for this project, and the satellites used will be those already in place for satellite phones. They want to enable global read coverage with a single terminal. The USA military alone has invested over $600 million to achieve TAV goals. Contracts have already been placed with Savi Technology and the UK DoD has also recently placed a contract with them for real time container visibility.
Background information on the Military's Joint Total Asset Visibility (JTAV) program
During Operation Desert Shield/Storm, the responsiveness of the logistics systems were degraded by thousands of

duplicate orders placed because operational units had inadequate visibility over the status of their requisitions. Moreover, an enormous amount of material was shipped to the theatre which was not readily available to forces because of poor control and poor visibility of assets - for example, printed labels and barcodes were sand swept and could not be read, so containers had to be opened for their contents to be known. Such problems reduced the readiness and effectiveness of combat forces and place unnecessary strain on the transportation system. JTAV was developed to avoid these problems in future operations. Initially the project has been awarded $600 million.

Bosnia/Kosovo improvements

The DoD has already benefited from the development and implementation of a Joint Total Asset Visibility capability : During military operations in Kosovo, most of the asset visibility short comings of Desert Storm had been overcome, and "warfighters" and logisticians supporting military operations were able to see material inside the pipeline. More recently, General Tommy Franks decreed that supplies bound for Afghanistan must be tracked with RFID tags.

2.6.2. Ministry of Defence, UK – military supplies

Company UK	Application Military
Benefits Sought Crime reduction Cost reduction	Status Roll-out (Ongoing)
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Price: $30.00	Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report

The UK Ministry of Defence announced a contract to deploy Savi Technology's RFID systems, infrastructure and consulting services to track and manage military supplies end-to-end while in-transit from storage depots to front-line operations. Information about shipment status and location - whether by truck, rail, ocean or air - will be captured in real time by a global network of fixed and portable handheld RFID readers, and transmitted to highly secured software systems operated by both the UK and MOD and the USA Department of Defence (DoD).

This was Savi Technology's first government defence-related partnership outside the USA DoD, for which Savi has helped build the in-transit component of the Total Asset Visibility (TAV) network, the world's largest active RFID cargo tracking system that spans over 40 countries and 400 locations using over 30,000 active tags.

The contract culminated a lengthy process by the UK MOD to leverage proven best-of-breed Automatic Identification Technologies (AIT) to improve operational efficiency and administrative productivity, speed up deployment and response times, cut costs associated with excess inventory, and automate and unify fragmented data bases by using a common information infrastructure.

"Logistical problems during Desert Storm more than a decade ago led the USA Department of Defense to deploy RFID technologies and software on the internet to improve real-time visibility and management of military supplies", said Mark McGlade, Savi's EMEA Managing Director. In Desert Storm barcodes were used to tag 30,000 plus containers, but these were quickly worn away under the desert conditions and each container had to be opened for its contents to be revealed. Since then, the US Military have invested $600 million(technologies to help overcome this in future - a project called JTAV (Joint Total Asset Visibility). Active tags are used for real time location of containers, but eventually the military wish to tag each individual item - and ID is not sufficient, they are also demanding sensors to prove temperature excursions, shock, pressure and so on.

Betsy DeLong of the USA Navy said, "This technology has been proven day-in and day-out to monitor and dynamically manage routine and rapid-deployment shipments more efficiently in real time. Equally important, this solution leverages existing capabilities and infrastructure - making start-up faster and providing a common information platform where partners can share critical shipment information in a secured environment."

An earlier USA contract was Savi's third multi-year RFID procurement contract with DoD since 1994, for a combined total

contract value of $280 million. During this time, Savi has helped to build and operate and continues to extend the DoD's Total Asset Visibility (TAV) network, already the world's largest active RFID logistics tracking system, which monitors and manages 270,000 cargo containers transporting military supplies throughout 400 locations in more than 40 countries. RFID tags along with a wide variety of AIDC technologies from Bar codes to satellite systems are affixed to cargo containers and other conveyances. The real-time data that these systems automatically capture is integrated into a global software network to provide immediate information on the location and status of the containers and their contents.
Savi will be responsible, in conjunction with the Army's Product Manager for Automatic Identification Technology, in responding to military proposals for real-time solutions provided by the company and through strategic alliances with market-leading automatic identification technology providers. The procurement contract calls for five types of RFID technologies : Passive, Active, Beaconing, Portal-based, and Real Time Locating Systems (RTLS). The contract calls for three years of equipment purchases and two years of training and maintenance services.
In the UK, Savi's contract with the Defense Logistics Organisation (DLO) initially called for affixing about 15,000 410 Series SaviTags onto conveyances such as ISO containers and pallets that are moved by trucks, rail cars, ships and air cargo planes. The smart tags communicate over UHF (#433 MHZ) radio frequencies with strategically placed readers, which in turn transmit information on the status of the shipment to a web-based software system used by the UK MOD. The result enables the British Army, Royal Air Force and Royal Navy to have real-time visibility of the conveyances and their contents, which range from food to ammunition, while being moved in-transit from abut 20 UK depots to operational sites.
The order also called for sophisticated handheld reading devices, fixed and portable automatic data collection readers, as well as Savi's patented "Retrievers", which process and translate the data from the RFID hardware Readers into computer language understood by software systems used by both the UK MOD and USA.

2.6.3. NATO Supreme Allied Commander Transformation (SACT) assets

Company NATO's Supreme Allied Commander Transformation (SACT) Europe	Application Military
Benefits Sought Speed, Cost reduction, Security	
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Read/Write Label	Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report
NATO's Supreme Allied Commander Transformation (SACT) commands NATO's military body. In October 2003, the US Department of Defense offered to share its global RFID-enabled In-Transit Visibility (ITV) network with NATO, provided the latter added compatible infrastructure to plug into the system. The DoD offer was made to help improve supply chain visibility and communications during joint operations.

Following a four-month evaluation, NATO chose to use the same proprietary solutions used by the DoD and the British Ministry of Defence that are designed, developed and installed by Savi Technology. In early 2004, SACT entered into an agreement with Savi for a pilot project using RFID technology, linked with Savi's SmartChain platform, to manage and track multi-national consignments between Europe and Afghanistan.

The project will help determine whether NATO and its 9 member countries will be able to use Savi's platform and RFID technology to enhance logistics operations and will be evaluated for possible future expansion.

Under the contract, Savi will install a network along the International Security Assistance Force Afghanistan supply chain, which runs from the Netherlands and Germany through Uzbekistan to Kabul. Each consignment will have a SaviTag-654 attached to it, and fixed interrogators will capture and convert the data generated by these tags into information that can be managed by users of the highly secure NATO information network.

In the first phases of the pilot project, Savi will conduct site surveys, perform installation work, train users and integrate the Savi SmartChain software into NATO's existing information system.

2.6.4. Department of Defense, USA – medical supplies

Company	Application
Department of Defense medical supplies USA	Military
Benefits Sought	**Status**
Error reduction Cost reduction	Roll–out (Complete)
Tag	
Supplier: Savi Technology	Interrogator: Savi Technology
Frequency: UHF (433 MHz)	System Integrator: Savi Technology
Format: Active	
Price: $30.00	
Further Information Savi Technology: www.savi.com	

Report

During the Gulf War, US soldiers lacked material for combat readiness, while ports were overcrowded with shipments awaiting processing. In addition, soldiers could not decipher the contents of containers without opening them. Soldiers had to open 28,000 of 41,000 containers on the docks just to find out their contents. Without visibility of shipment status, personnel often created redundant requisitions, equating to $2.7 billion in excess repair parts.

After the Gulf war, the DoD tested and implemented track and trace technologies including RFID. Five years later, the deployment to Bosnia was the first time these technologies were implemented on a large scale.

The DoD hired Savi Technology to implement an Automatic Identification Technology (AIT) and Radio Frequency Identification (RFID) solution, employing a suite of technologies and providing process automation to capture, retain, retrieve, transfer and integrate data into a shared system. Savi provided in-transit and 'in the box' visibility, identified problems in the supply chain and provided solutions. The client demanded:

Increased productivity and limited human involvement.

Complete supply chain visibility in near real-time.

Elimination of redundant requisitions.

Expedition of goods from factory to foxhole and improve shipment confidence.

Elimination of redundant data entry and getting data accuracy.

When the pallet is filled at the depot, an Automated Manifest System (AMS) card and RFID tag are now attached, containing information on pallet contents, and the information is sent to a central information system. Readers located throughout the supply chain then track the shipment automatically.

Operators get the status of shipments from the central information system at any time, via Web-based software. When the shipment arrives detailed information on the contents is downloaded from the tags into the system. Goods can then be shipped to other locations through the same process. Data on the tag is also used to search for specific items in containers. AIT/RFID technologies provide total asset visibility and in-transit visibility in near real-time.

The benefits from implementing this system, on an investment of $5.1 million, included:

Eliminating excess - Previously, excess supplies might be sold back to wholesalers at 25 per cent of cost, despite being

needed at other locations. The solution saved $18.7 million, helping the client to redistribute excess material to other locations.
Avoiding demurrage - The solution saved $200,000 per year in demurrage.
Worldwide network coverage - AIT/RFID solutions in the Balkans have led to expansion of the network infrastructure, which has grown to over 1,500 data appliances, 350 site servers, and 20 data centers connecting over 30 countries.
Recovery of excess charges - Operators can track arrival and departure information against carriers' records, and were able to get refunds on delayed or lost shipments, saving $1.2 million in reverse charges.
Reliability - Average hourly operation readiness is 97 per cent worldwide for hardware.
Confidence and readiness improved.
Reduced delivery time - On average three days per shipment.
Return on investment (ROI) - The ability to locate medical supplies and equipment immediately ensures combat readiness and survival. The ability to read container content remotely from a tag was responsible for avoidance of life-threatening injuries at least twice. Soldiers get 'in the box' visibility and can protect themselves when opening unmarked containers.

2.6.5. Bosnia/ UK Military - supply chain.

Company	Application Military
Benefits Sought Crime reduction Cost reduction	Status
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Price: $30.00	System Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report
Total spend on Global Supply Chain annually is $3 trillion. It is estimated that the loss and waste due to poor supply chain visibility is 6-10 per cent, or somewhere in the region of $180-300 billion. It is this waste that they seek to eliminate with their comprehensive supply chain management solutions. By way of example, In the work for the UK Ministry of Defence, Savi Technology thought that if they could just put in some middle layer which unified all the disparate information systems, it would give them Total Asset Visibility (TAV), the holy grail when it comes to getting supply chains under control. However, without automatic, real-time data capture, data could take two to three days to get on the system. This could never be considered real-time TAV. They concluded that getting the data onto the system is an important consideration. This has been implemented by a multi-level identification system, with the appropriate technology used at each level - barcode and passive RFID, active RFID and then GPS at the top level.
This learning was implemented in an interesting project for the USA Department of Defense. Between 1997-1998 Savi Technology was awarded a $5.1 million contract to implement an RFID solution for the military supply chain to Bosnia. Several years on they have seen cost elimination and avoidance benefits to the tune of $18.7 million, a very respectable return on the investment. As part of their infrastructural development, Savi can boast full scale readability at Rotterdam and Felixstowe ports with readers installed on all road, rail and shipping routes into the ports, and on each of the quay cranes.

2.7. Case studies of active RFID in logistics

2.7.1. NYK Logistics, USA – intermodal freight containers

Company NYK Logistics USA	Application Land and sea logistics
Benefits Sought Inventory control, Improved data capture, Speed, Cost reduction, System automation, Efficiency	Status Roll–out (Complete) Start: 2002 Payback: 2 months
Tag Supplier: WhereNet Frequency: Microwave (2.45 GHz) Format: Active Large tag about the size of a videotape Range: 300 meters Price: $200	Interrogator: WhereNet Interrogator Price: Thousands of dollars System Integrator: WhereNet Project Cost: Around $500,000
Further Information WhereNet: www.wherenet.com	

Report
NYK Logistics of Secaucus, New Jersey USA, had a big parking problem. The company manages the shipment and distribution of a high volume of products, including garments and accessories, consumer and industrial goods, computer software, food and beverages and natural resources for Global 1000 companies. Unfortunately, NYK's yard-management system was no match for the more than 50,000 inbound ocean freight containers and 30,000 outbound trailers passing through the gates of its Long Beach, Calif., distribution center annually.

RTLS
The company implemented a Real-Time Locating System RTLS at the Long Beach facility that uses battery-powered (active) RFID tags to track the location of assets in the yard. Now NYK knows exactly where each trailer and is parked and can locate containers to within 3 meters. The system has cut costs and increased operational efficiency, including reducing the average turn time—how long a trailer stays in its yard—by 20 - 40 percent.

Removing staff costs and errors
NYK's old yard-management system at the Long Beach facility relied on people to track containers and trailers manually, and to coordinate the seven hostler tractors used to move containers around its 70-acre yard. But the manual system lent itself to a number of problems, and as volume in the yard grew, the problems were compounded. For example, NYK employees used to manually enter information about when a truck arrived at the yard, what it was carrying and where it would drop its load. But once the driver left the main gate to drop his cargo off and pick up his next shipment, snafus were common. Often, the designated parking spot was filled, forcing the driver to park in a different spot. Employees at the main gate would have no way of knowing where the truck was. The problems multiplied through the yard as subsequent drivers found their spots taken for the day.

Manoeuvring difficulties

During peak seasons, NYK hires temporary yard hostlers to pull loaded trailers out of their parking spots and stage them in the yard for pickup. The hostlers also retrieve empty containers and move them to appropriate areas. However, the temporary drivers had difficulty manoeuvring through the yard. "We're a 24x7 operation, so the guy driving around trying to find a trailer at 3:30 in the morning when he doesn't know the yard that well can run into problems," says Rick Pople, NYK's general manager.

Pople joined NYK in February 2003 after working for courier companies DHL and FedEx. He began searching for an automated yard-management system that could eliminate these headaches and help NYK create a more organized yard.
Barcodes inadequate
The company considered bar code-based technology
but decided against it because it had too much human intervention and potential error – much like the existing manual system. "Although the bar code was associated with the unit, the unit still had to be associated with a location," says Pople. "So if a driver doesn't follow instructions to record that data, we'd be back to square one."

Tag attached at the gate

Source: Wherenet

Active RFID to the rescue

Pople decided to use an active-tag RFID system from WhereNet, an RTLS provider based in Santa Clara, Calif. WhereNet was the only RFID vendor the company considered because it was the only company that had a real-time-location yard-management solution. The entire system took 90 days to deploy. Thirty-five WhereNet readers were installed around the perimeter of the yard. They monitor 1,100 parking spaces and 250 dock doors. When a truck arrives at NYK's entrance gate, it trailer is tagged with a WhereNet transmitter. The tag broadcasts its ID signal at three regular intervals as the container moves through the yard. Each signal is picked up by a different reader. Software uses those signals, along with a time stamp that indicates when the signal was transmitted, to calculate the exact location of the asset to within 3 meters.

Real time is crucial

All this happens in real time, which is critical because the yard operates around the clock. NYK's three logistics partners bring in containers from 11 different steamship lines and as many as 15 different domestic carriers. "We couldn't have enough people with clipboards and bicycles to monitor all that," he says.

NYK has now implemented a dual-process system. When a driver enters the yard, a worker uses a handheld computer to enter information about the driver by scanning the magnetic stripe on his driver's license into the system. Then the worker attaches a WhereNet tag to the container or trailer. The tag is fastened using a clip mount on the container or trailer and removed before the container or trailer leaves the yard. The tag is scanned and the unit is associated with the driver. The system then prints a ticket for the driver that tells him where to park the unit he is delivering and where to find the unit he needs to pick up. This has cut check-in time at the gate in half.
Integration with legacy systems

NYK integrated the WhereNet system with its own Transload system, a custom database that contains a list of advance shipping notices, the contents of the shipment and distributor information. As a result, workers can use a handheld RFID reader to scan the container's tag, find out its contents and receive instructions on where to take the container.
"Not only do we know the name and identity of the unit, we also know its DNA," says Pople. "We can see the yard and the containers."

The WhereNet yard-management application and wireless network has enhanced speed of operations but it has also saved money.
"The biggest cost component for us is space, and if you don't have a highly organized yard, you are probably using more space then you need to," says Pople. NYK measures space in terms of turn time which is the amount of time a trailer stays in its yard. Since it launched

the WhereNet system in June 2003, it has been able to reduce the average turn time from 10 hours to between six and eight hours. Depending on how busy the yard is, taking two hours off of turn time can save anywhere from 35 to 60 parking spaces.

Faster finding and moving

Hostlers are also able to improve the time it takes to find and move loaded trailers and empty containers, because each hostler tractor is equipped with a touch-screen computer that hooks into the WhereNet system. The system wirelessly communicates the precise location of whichever trailer the hostler driver is instructed to move and provides a map of the location, which helps temporary workers manoeuvre through the yard. Pople says the system has made NYK's full-time workers more efficient, so the company has not needed to hire as many temporary workers, even in the fall (autumn) which is its busiest season.

Hostlers get instructions via wireless terminal.

Source: WhereNet ›

Hot loads

The system can even flag "hot loads," the shipments with the highest priority. It sends alerts to a hostler driver's touch-screen computer with instructions on which loads to move first.

Time and cost saving

NYK has also been able to save time and cost by using the WhereNet system to standardize the way in which it communicates with its carriers and logistics partners. Prior to implementing the system, some carriers required faxes, others had Web sites where data needed to be entered, while others wanted to receive e-mail messages. Now, the WhereNet system automatically sends e-mail messages three times a day to all relevant parties to relay pertinent information about shipments and containers.

The WhereNet system automatically updates the location of a trailer: if a driver parks in the wrong place, the system recognizes the new spot and updates the database. Subsequent drivers entering the yard are then directed to empty spots. The company plans to monitor how well the drivers follow instructions and to alert partners and carriers if their drivers continuously park in the wrong spaces.

Reduced detention charges

NYK has also reduced detention charges levied by shippers by using the new system. The company, its partners or distributors could be charged detention fees if empty containers aren't returned to the port on time. The WhereNet system includes a tool that helps managers see which dock doors have trailers at them, what's inside that trailer and how long the container has been there. Managers can see when a trailer has been delayed at a door and investigate. They can also better manage the flow of trailers through the yard by assigning drivers open doors when they arrive at the gate.

A WhereNet reader

Source: WhereNet

By reducing traffic jams at the dock door, containers move through the facility more quickly and are returned before NYK can be charged detention fees. Moreover, if a shipper tries to tack on unwarranted detention fees, NYK now has the means to challenge the charges. That's because the system flags empty containers and records precisely when it left the yard.

Prioritisation by rules engine

WhereNet also added a new rules engine to the application suite that is designed to help companies reduce shipping costs. NYK has arrangements with many carriers, and some of those carriers charge more than others to move loads out of the yard. The new rules engine will automatically queue up the least expensive carrier to service a route. If the primary carrier isn't available, the system will move down the list to the next least expensive carrier that's available; it will queue up the most expensive carrier only when the system gets to the end of the list.

Future expansion

The company has about 800 tagged units in the yard at any one time and processes about 700 gate transactions (trailers entering or leaving the yard) a day. In its busy fall season, the volume increased and this was real test of the system. It is now be easier to measure the return on investment., because the company now has time to calculate the ROI and gauge the efficiency of the system. NYK says may consider using the WhereNet system in more of its facilities (13 nationwide)but it has not made any decisions about future deployments as yet.

2.7.2. Fluor Construction, USA pipe spools

Company Fluor Construction USA	Application Manufacturing
Benefits Sought Cost reduction, efficiency, system automation, speed	Status Trials
Tag Supplier: Identec then Phase IV Engineering Frequency: UHF (915 MHz) Format: Active Read/Write Range: 100 meters Price: About ten dollars* Number of Tags: Potentially 10,000 tags per project	System Interrogator: Identec then CargoWatch Interrogator Price: Thousands of dollars* System Integrator: Shaw Industries/ Fiatech Project Cost: ultimately millions of US$*
Further Information Identec then Phase IV Engineering: www.identecsolutions.com Identec then CargoWatch: www.identecsolutions.com *IDTechEx estimate	

Report
In September 2003, an RFID trial was conducted at a pipe fabrication plant in Houston, Texas USA to determine whether RFID could help automate the shipment and delivery of key materials from fabrication plants to construction sites. One key goal was to see if the technology could stand up to the rigors of harsh construction industry environments.

The three-phase trial was hosted by Fluor Construction, one of the world's largest, engineering, procurement, construction and maintenance companies. Fluor partnered with one of its materials fabricators, Shaw Industries, to help deploy the RFID trial at Shaw's plant.

Overseen by trade consortium

Also overseeing the project was Fiatech, a non-profit consortium of construction companies, material suppliers and academics focused on speeding the development and deployment of technologies in the construction industry. Fiatech was formed by the Construction Industry Institute of the US, the University of Texas and the National Institute of Standards Fire and Protection Laboratory in the US.

In addition to providing expertise, "Fiatech brings other construction companies, fabricators and clients into the examination of the potential for RFID in the construction industry," said John Wadephul, supervisor of field materials management at Fluor, which is based in Aliso Viejo, California in the US and has offices in more than 25 countries across six continents.

Caution

Fiatech was cautious regarding the technology.
"We had heard of trials years ago where passive RFID failed to demonstrate any advantage over barcodes," says Charles Wood, project manager at Fiatech. "RFID readers had to be so close to the tags to get a reading that they required the same kind of manpower and line of sight as barcodes."

Spools

For the trial, Fluor wanted to tag spools. A spool is a unique section of steel or carbon steel piping that is later welded to other spools on the construction site to create pipes that meet exact design specifications. Spools can range from two inches to eight inches in diameter and be up to 40 feet in length.

"We wanted to tag the items that we have a hard time keeping track of," says Wadephul. "These pieces stand on top of each other. There is no line of sight."

Normally, spools are barcoded at the fabrication plant, then shipped to the construction site where the delivery is checked. However, "Most spools have a bar-coded label on the spool and one on the packing list, but rather than locate the label [on each spool], it is usually easier to identify each spool visually and later, inside the office, use the bar code on the packing list to record the delivery," said Wadephul.
RFID advantage is automation

The potential advantage of RFID is to automate and hasten the delivery and inventory identification process and eliminate the need for visual checking or line-of-sight reading that bar codes require—especially given that these pieces are not neatly stacked when they are transported. If RFID technology worked on spools, the potential market would be significant. "A single project can use between 1,000 and 10,000 spool pieces," says Wadephul.

The first phase of the trial sought to see if tags could work in an environment surrounded with metal. Radio waves used by RFID bounce off metal, creating the potential for reading errors when tagged objects are metallic and are read in environments containing lots of other metal. Fluor and Fiatech turned to Identec Solutions based in Germany for its active (with battery) tags and readers.
"This is the worst environment you can put a tag in," says Barry Allen, president of technology at Identec.

Environmental challenges

In the first phase of the trial, the goal was just to find a tagging technology able to meet the demands of the environment. Between 20 and 30 spools were tagged with Identec's iQ active tags to see if the tags could be read from a distance of 3 meters. The two by four by half-inch tags operate at 915 MHz with a read rate of up to 100 tags per second (identification code only) or up to 35 tags per second (128 bits of data). In addition, for multitag reading, the readers can handle of up to 2,000 tags in the read zone and offer a read-write range of up to 100 meters (328 feet) in free air.

Tags on pipe spools.

Source: Identec

Spools were loaded onto a truck and tagged, and readings were taken manually by a worker walking around the perimeter of the truck using an Identec reader card inserted into an iPaq handheld PDA. The reader successfully read the tags 100 percent of the time and demonstrated a read range of around 10 feet.
Identec believes that its active RFID technology was extremely well suited for this application.
"This is exactly the kind of application that our long-range active RFID was designed for, and it has already more than proven itself," says Identec's Allen. "One of our customers has deployed more than 100,000 of our tags over the past four years in a similar environment."

Potential second source

Having established that the tags could be read, the trial moved into a second phase, where fixed readers were installed and a truck loaded with spools was driven past the readers to replicate the dispatch from the fabrication yard. For this phase, the trial used the newly developed CargoWatch RFID readers and active tags from Phase IV Engineering of Boulder, Colorado USA. The reason for switching tag and reader manufacturers was to prove that workable systems were available

from more than one vendor, says Fiatech's Wood. Developed for the U.S. Navy and currently undergoing testing on tag munitions palettes, the CargoWatch tags hold 500 kilobytes of data and operate at 433.92 MHz. IDTechEx note that this frequency is particularly good at diffracting around metal objects the size of these pipe spools. The tags adhere to no standard: "Nothing has emerged in this space yet," says Rich Pollack, CTO at Phase IV Engineering.

Portals tested

In this phase of the trial, RFID tags were attached to spools on a truck that was driven through a trial portal constructed in the pipe fabrication yard. Once the test team worked out the best way to determine accurate readings, they were pleased with the results. "It was a success. We came up with a method to record 100 percent accurate readings by stopping the truck," says Wood. "The truck stopped only for a moment and then started. This procedure helped us coordinate the timing of the read in the tests where we were collecting more than just the IDs. As I recall, we missed a few of the tags on a few of the trials where we did not stop the truck."

Damage prevention and improved readability

The test team found the best way to connect the fairly bulky RFID tag to a spool without later damage. Mounting the tag either inside the pipe or on the underside of a bracket welded to the pipe would hamper the ability to get a reading. Instead, the tag had to be mounted flat on the outside of the pipe surface. But an even better reading was gained by letting the tag hang loose from the spool.
"Most consistent readings came when tags were not attached," says Wadephul. "With a hole in the tag, we can use a plastic tie or wire and let the tag swing free."

For the trial, the spools were tagged after placement on the truck, so that issue has not yet been addressed. But there is little concern among the trial organizers. "Tags are somewhat ruggedized, and I am sure there is technology out there to protect tags," says Wood. "It's not a big issue."

While the first two stages of the testing in 2003/4 proved that RFID can be used in such an environment, questions still remain about the potential benefits and costs of deploying the technology in the construction industry according to the purchasers.

Phase 3

The third phase of the trial, which started mid 2004, is expanding both the numbers of spools tagged as well as the number of trucks carrying the spools out of the fabrication plant.
"We are looking to run three or four trucks loaded with spools through a portal and make sure we get 100 percent read with different load configurations and with different spools," says Wadephul.

This trial phase will also help the company understand how much data to store on the tags. So far, each tag has held the same information that Shaw stores on the standard bar-coded labels it currently uses. This information includes details such as the project number, the client number and the drawing number that the unique piece relates to.

Scope for more data
"With tags coming with more and more memory, there are possibilities to store more information," says Wadephul. "But we have seen that more information slows down read times, so we will also look at putting less information on the tag and tying that to data on a central database."

Even if the third phase of the trial goes well and RFID proves to be a viable technology in the construction arena, the team that put together the trial maintains that RFID deployment in the building industry will still face some serious business hurdles.
Need for standards
"The [construction] industry has a history of being very difficult to set standards. We've seen this with other technologies," says Wood.

Agreeing upon a standard would be essential, according to Fluor, in order to make deploying tags at the fabrication plant a feasible option. "If there are a number of construction companies that decide to use different tags, there will be protocol problems in the fabrication plant and those plants will have to deploy different readers for different customers," says Wadephul. If different customers were to use different readers, that would greatly increase the cost and complexity of any RFID deployment and probably stifle any deployment plans. The Smart Active Label Consortium is among those working on standards for active tags but it is early stage as yet. Both functional and applicational standards are needed.

Cost a problem, including tag cost
Finding the budget to deploy RFID on a project-by-project basis would be another hurdle. "Construction is a very cost-sensitive industry. It is project-oriented, and the lowest bidder for a project usually wins the contract," says Wood. With wider industry acceptance of RFID, however, spreading the additional cost across contractors might offset the expense of RFID.

Fluor maintains that much of its own work is not project-based, but is charged to the client on a time and materials basis. If deploying RFID can be shown to bring savings either in construction time or cost, clients could lead the push to

demanding RFID be used on a contract.

"To get going on RFID deployment, we would need a little driving by our clients," says Wadephul. "If our oil, gas and chemical clients' plants see any advantage in RFID, they will be telling us to use it."

Saving assessment needed
Measuring the savings from RFID deployment is another task yet to be carried out. "But we do know that when the materials are in front of a worker, then he can work quicker," says Wadephul. No matter who deploys the RFID technology, Fiatech and Fluor agree that the cost of RFID remains an issue.

"I'm very concerned with active tag costs, although they are coming down in price. Every vendor I have talked to so far is charging above $50 per tag. With a single job potentially using 10,000 tags a shot, the economics is not inconsiderable," says Wadephul.

He says that there are ways to offset much of that outlay. Active tag batteries can last up to 10 years, so Fluor is looking into recycling tags and using them on multiple projects. "As projects last one to two years, we could get five projects from a single tag," says Wadephul.

This recycling could also help generate new business. For example, fabrication plants and material suppliers could attach tags to their wares and then charge an additional ongoing fee until the project no longer needs the tags and the project manager returns them. But this could only be possible if the hoped-for construction-industry RFID standard emerges.

"With a single RFID standard deployed across the construction industry, a fabrication plant could install the tags, and construction companies would pay a rental fee for each tag for the length of the project," says Wadephul.

Despite the active tags' ability to perform successfully in the trial, both Fiatech and Fluor argue that if passive tags can ever be shown to perform as well as or better than the active tags, then passive tags—which cost far less than active tags—might be used instead. But there are no plans to run similar tests with passive RFID.

Wood said that during a planned February 2004 meeting in Houston, Fiatech planned to present its members with academic papers on the RFID trials. Fluor hoped that the greater exposure of the trial's findings will generate wider interest in deploying the technology across the construction industry. We do not yet have a report on that meeting.

2.7.3. Brink's, USA – transport container access

Company Brinks France	Application Land and sea logistics
Benefits Sought Crime prevention, staff safety	Status Roll–out (Complete)
Tag Supplier: EM Microelectronic Format: Active Range: 10 cm and long range Price: At least $10* Number of Tags: 4000 in 2004, 15000 each subsequent year	Interrogator: EM Microelectronic Interrogator Price: Over one thousand dollars* System Integrator: EM Microelectronic Project Cost: hundreds of thousands of US$*
Further Information Brinks: www.brinks.com EM Microelectronic: www.emmicroelectronic.com *IDTechEx estimate	

Report

Brink's Inc., of the USA is the oldest and largest security transportation business in the world. The company provides services worldwide, including deliveries by armoured truck, cash counting, cash management and coin processing.

Brink's handled luggage for delegates to the Republican presidential convention in Chicago in 1860 when Abraham Lincoln was nominated. It has transported the U.S. Declaration of Independence, the first rock samples astronauts brought back from the moon and the world's largest uncut diamond, among other valuables.

Ink staining versus acid.

Source: Brinks

RFID for self destruct

In Europe, trucks are smaller and have half the armour of U.S. trucks, and the police may respond less quickly to crime. Because of these differences, Brink's France tested an RFID-based system in 2003/4 that performs a unique function: banknote shipments that self-destruct when anyone tries to steal them from an armoured car.

Assaults worsen

The pilot for the new system, which began in June 2003, came at a time when robbers increasingly had targeted the funds transport industry, and the attacks had become increasingly violent, according to Brink's. During the previous five years, the company's vehicles were held up 15 times in Europe. In some countries, including France, the government is encouraging the transport industry to use electronic devices that destroy funds when someone is trying to pilfer them. The hope is that this will discourage theft and thereby reduce the number of crime-related injuries or fatalities to personnel.

Exploding dye packs

Most funds transport companies use exploding dye packs to mark the stolen notes in order to discourage robberies because anyone trying to use a note smeared with dye risks being arrested. However, Brink's determined that dyeing is always reversible. Banknotes are made with cellulose that is similar to the material used in T-shirts, said Philippe Besnard, research and development manager at Brink's in Paris. If a shirt is dyed or stained with ink, the dye or stain can be removed with commercial products. The same is also true with the notes. Anyone who steals banknotes could remove the die and reuse them.

Surprise

This discovery caused surprise among the central bank, bank customers and France's Internal Affairs Ministry, says Besnard:
"All other companies are still using dyeing [technology] from 15 years ago."
But Brink's has developed and patented a destruction technology based on the oxidation of the cellulose with strong acids and triggered by a battery-powered RFID tag.
Background

Prior to joining Brink's France, Besnard worked as a system architect at RFID system provider Sensormatic, in Boca Raton, Fla. Having developed RFID tracing and tracking systems for Sensormatic, he was familiar with the use of RFID technology for security applications. Brink's France did not consider any other technologies for the project, Besnard says, because "RFID was the only way to obtain the result we had to look for."
EM Microelectronic one stop shopping

After a study of existing technologies, Besnard asked EM Microelectronic, the chipmaker from Marin, Switzerland, making complete RFID systems, to devise a new solution for destroying funds. Other RFID suppliers could not provide the technology and service that Brink's needed. EM Microelectronic specializes in low-cost and ultra-low-power-consumption chips that matched the requirements of the system Brink's wanted to implement.

"The very low voltage and very low power technology is a key advantage for this project," said an EM Microelectronic spokesman. The system requires minimum-size batteries that operate for at least two years, which keeps maintenance costs at an acceptable level. Because the semiconductor company's product development is focused mostly on passive RFID technology, says the spokesman, it had to draw upon the expertise of its various business units to create the system for Brink's.

Brink's box

With the system that EM Microelectronic developed, funds are carried in a B-Box (or Brink's Box), a 560mm by 250mm by 150mm plastic-clad case that can hold as many as 4,000 notes. The box's metallic interior is designed to withstand the chemical reaction, which can cause the temperature to reach 200 degrees Celsius. Incorporated into the box are an active RFID tag and a device loaded with chemicals that destroys banknotes when triggered.

A Brink's employee puts money in the B-Box corresponding to the customer requirements, which are stored in a back-office application and transmitted to the employee's handheld PDA. The back office application calculates a unique code, which will be used later to open the B-Box, and transmits that code to the B-Box via a 125-KHz short-distance RFID reader (10 cm). The back-office application determines the opening code using several parameters: the B-Box's tag number, the customer's ID code, the number of an RFID tag assigned to the customer and the PDA ID. The employee closes the B-Box, which becomes armed automatically in self-protection mode. While in this mode, the B-Box will destroy its contents if anyone tries to open it by force.

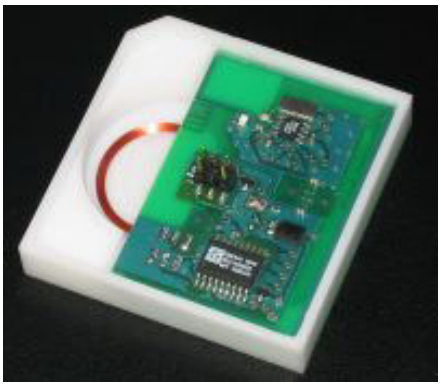
Armoured truck

The Brink's employee loads the boxes onto the armoured truck, which can hold as many as 30 B-Boxes and has a long-distance (five-meter) 868-MHz RFID reader. The truck's reader sends a periodic message to all the B-Boxes, each of which is waiting for the periodic message. If someone tries to remove a B-Box from the area or if the truck's reader is destroyed, the B-Box doesn't receive the periodic message. After a predetermined time (for example 20 seconds), each B-Box triggers its own destruction. If the truck is attacked, the driver may also trigger the destruction of the box.

Spatial diversity
Brink's avoids signal interference or accidental blocking of the signal that would trigger destruction of the funds, because the transmission is based on spatial diversity and the system employs two antennas that are used alternatively, the EM Microelectronic spokesman says. In addition, an encoding scheme is used in order to maximize the signal-to-noise ratio.

While being transported, the B-Boxes can not be opened without triggering their content's destruction. The employee's PDA does not contain the opening code, needless to say, because that would put the employee in danger. The opening code resides solely inside the memory of the B-Box, and it is not possible to calculate the code without having the B-Box, the employee's PDA and the customer's RFID tag number.

The truck is tracked via the Global Positioning System. When it pulls up to the customer destination, its GPS coordinates match the preprogrammed coordinates in the system. The system then activates the PDA, enabling it to send a message to the truck's reader that causes the B-Box to go into "pedestrian phase." This means the B-Box does not require periodic messages from the truck's reader, although the B-Box remains in self-protection mode. Once inside the customer facility, the Brink's employee's PDA reads the customer RFID tag ID and calculates the opening code for the B-Box.



The EM Micro active RFID tag.
Source EM Microelectronic

Fail safe

The PDA transmits the code to the B-Box through the 868-MHz RFID link. The B-Box compares the code with the existing code in its memory. If the codes match, the B-Box unlocks itself, and the Brink's employee is able to open the B-Box and remove the notes. If the codes do not match, the B-Box remains locked and in self-protected mode until its batteries are close to low level or somebody tries to force the B-Box open. Either of those events will cause the destruction of notes.

Notes are recoverable through the bank
The funds that are damaged by the system are not totally destroyed. About 50 percent of each note is burned, which is enough to prevent thieves from using them.

"Destruction of the banknotes is preferable to theft because they cannot be used anymore," Besnard says. A destroyed note is returned to France's central bank and exchanged with new notes. French government regulations require that at least 20 percent of each side of the note must be present in order to be exchanged, he says.

2004 rollout

In 2003,Brink's France limited use of the RFID system to the pilot program. So far, in 2004, no robbery has been attempted and therefore, no money has been destroyed. The company rolled out the system in the middle of 2004. Besnard and the EM Microelectronic spokesman say the companies have not encountered any serious problems while testing or deploying the technology.

Build up

The Brink's schedule calls for deploying 4,000 RFID-enabled B-Boxes in 2004, 15,000 in 2005, and an additional 15,000 each year for several years after that. The development plan calls for 30,000 B-Boxes for Brink's France, 30,000 for the rest of Brink's Europe and 30,000 for Brink's France customers who have agreed to take part in the program. The customers include La Poste (the French postal service), Paris Metro, French retailer Casino, and banks Credit Lyonnais and BNP Paribas.

Brink's initially plans to use the technology only in Europe but will consider using the system in the U.S. market later on, says the EM Microelectronic spokesman. Ed Cunningham, a vice president with Dallas-based Brink's in the United States, declines to comment on any security technology the company is using or plans to use.

Broad potential in security
EM Microelectronic says other European funds transportation companies, as well as banks and retailers, have expressed interest in the system and may use it or something similar. A similar type of radio-controlled system could be deployed to secure high-value items in the supply chain, without destroying them. For instance, such a system could be used to trigger an alarm if valuable items such as PCs or works of art were removed from a detection field.
The number of tags used in the project will be 4000 in 2004, 15,000 in 2005 and 15,000 each subsequent year - more if used in US as well. The end point for France is 30,000 units. Payback on the project is uncertain because crime occurs intermittently.

2.7.4. Felixstowe Dock & Rail Company, UK – Rubber Tyre Gantry Cranes RTGC handling intermodal containers

Company Felixstowe Dock & Rail Company UK	Application Land and sea logistics
Benefits Sought Efficiency, accuracy	Status Roll–out (Complete) Payback: 2 years*
Tag Supplier: Avonwood Frequency: LF (132 KHz) Format: Active Read/Write Range: 65 cms Price: a few dollars* Number of Tags: Over 500	Interrogator: Avonwood Interrogator Price: A few thousand dollars* System Integrator: Avonwood
Further Information Avonwood: www.avonwood.co.uk *IDTechEx estimate	

Report
Avonwood report as follows © Avonwood Developments

EUREKA RFID Tags providing location details for Rubber-Tyre Gantry Cranes (RTG's) within a container port

It is of strategic importance that container ports are able to service rotation ships fast and efficiently. This means that the turn around time for servicing these ships must offer a minimum deviation for the largest ships to make their economies of scale count.
Container ports are very proactive in investing in the latest technology to ensure they remain efficient and effective in an extremely competitive market.
Utilising state-of-the-art technology demonstrates a commitment to customer care. And, in an industry where time is of the essence, selecting automatic identification, in particular RFID, assists in a fast and effective service.

Trinity Terminal - Felixstowe Dock & Rail Company, Felixstowe, Suffolk England

Trinity Terminal at Felixstowe is the largest container handling facility in the UK, it has the longest continuous quay in the British Isles and leads the country in computerised cargo control. The terminal regularly handles in excess of 120,000 containers, 170,000 TEU's (20ft Equivalent Units) each month.

Integral to their automated systems are over 36 Eureka Decoders each one being housed on an RTG which in turn process data from in excess of 500 311 RFID (Radio Frequency Identification) Tags. The container yard is laid out in a matrix with rows and columns with each row/column being identified by a Tag. These Tags are buried in the ground along the channel where the RTG's wheels travel.

The Decoder on each RTG is connected via an RS422 serial link to the on-board system in the RTG's "E" House (electrical house) which in turn sends the information received from the EUREKA 311 RFID Tagging System to the main computer room over a Radio Data Link.

Source: Avonwood

The Eureka 311 Tag

Each Eureka 311 Tag operates as a miniature radio frequency read only transponder. It is normally in a quiescent state, but when it comes within range of a radio frequency field produced by the interrogating antenna, it is activated and transmits its data back to the decoder via the antenna. The radio frequency communications, to and from the Tag, utilise low frequency inductive coupling, and can therefore function through most non-conductive materials, allowing Tag operation in very difficult and harsh environments. A long-life lithium battery maintains the Tag's data memory, and provides the small amount of power needed to transmit data from the Tag. Because of this the Tag is referred to as an "Active Transponder".

System Operation

There are over thirty RTG's operating in Trinity container yard, each one fitted with an Antenna under the mesh floor of the checkers cab. To help achieve accurate location information of an RTG, Felixstowe Dock & Rail Company utilise a Eureka 311 Tag. The container yard is laid out in a matrix of rows and columns, and at the start of each row a Eureka 311 Tag is buried in the ground providing a unique ID. This is then used to give an accurate location of the RTG, within the container yard.

Having real-time information on any RTG's movements within the container yard, enables scheduling to be carried out to direct it on a pre-programmed route.

Conclusion

By using Eureka 311 Active Tags to uniquely identify RTG's locations, the loading and unloading of containers with waiting lorries is streamlined and automated.

2.7.5. Agricultural Cooperative, France – vehicle tare weighing

Company French Agricultural Co-Operative France	Application Animals and Farming
Benefits Sought Speed, Error prevention, Improved data capture	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only Card Range: Up to 5 meters	System Interrogator: TagMaster
Further Information TagMaster: www.tagmaster.com	

Report
An agricultural co-operative in France is using RFID technology to help deal with deliveries at its collection centre just outside Metz. During the busy harvest season, the Co-Operative experienced serious problems with traffic congestion in and around the collection centre, as farmers from all over the region brought their loads of grain and corn to be weighed and analysed for moisture content. The registration processes at the entrance, weigh-bridge and grain analyses points were manually operated and inefficient documentation procedures caused the farmers costly delays.

With the new RFID-based system, provided by TagMaster, the farmer arrives at the collection centre and registers, receiving an RFID tag straightaway from an automatic dispenser. He then places this tag in a holder on his vehicle. The vehicle and grain load is automatically identified and registered by interrogators at the weigh-bridge, product analyses station and unloading points. Once delivery is complete, the tag is returned for re-use by subsequent arrivals. Delivery documents can now be produced automatically by the system.

2.7.6. Yard management, USA

Company Yard management USA	Application Land and sea logistics
Benefits Sought Speed Cost reduction	Status Roll–out (Complete)
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Price: $30.00	Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report
Savi Yard Management helps US 3PLs and shippers manage all aspects of yard operations. Yard supervisors, in-bound and out-bound logistics co-ordinators, and dispatch operators use the web and wireless handheld devices to track receiving and shipping, allocate space, and manage truck movement throughout the yard.
Challenges in yard management
All too often, truck yard supervisors do not have the tools or information they need to manage the yard efficiently. Relying primarily on yard hostlers to fill out paperwork a trucks move into and within the yard, critical information is invariably lost and costly mistakes are made. Not knowing where trucks are located, what they contain, or when they should be unloaded makes it difficult to optimise slot usage prioritise container unloading, and manage space during peak demand. Without knowing when a specific trailer can be unloaded or moved, demurrage charges accumulate and shipments fall behind schedule.

2.7.7. Spittelau Thermal Waste Treatment Plant, Austria – trucks

Company Spittelau Thermal Waste Treatment Plant Austria	Application Land and sea logistics
Benefits Sought System automation, Speed, Reduced congestion, Improved data capture	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read/Write Card	Interrogator: TagMaster

Report
The Spittelau Thermal Waste Treatment Plant in Vienna services a major part of the 1.5 million people who live in the city. It is located near to the busy city centre, in an area that has heavy traffic. On entering the plant, each waste truck needs to be registered, weighed and then directed to a specific tipping point. Traditionally, the arrival of waste deliveries was concentrated during the morning and afternoon rush hours, creating long queues of trucks outside the depot and making the delivery procedure a long and inefficient process that required significant manual processing time.

The depot needed to speed up the flow of traffic through its gates and to gain reliable and accurate vehicle identification and load weight information. In order to address this need, the depot chose an RFID system from TagMaster.

Ten long-range interrogators were mounted above the weight bridges at the plant's entrance, and at the exit gate. The waste trucks were each fitted with 2.4 GHz tags, which were permanently mounted on the windshield. When a truck passes the entrance, its tag is scanned to get its identification details and it is weighed and registered before being moved on to its allocated tipping point. On leaving the plant, the vehicle's tag is read again by the interrogator on the exit gate. All the truck movements are recorded by the TagMaster system and passed to the plant's central database.

Installing the RFID system means that the waste trucks can now pass through the entrance and over the weight bridges without needing to stop for manual checking. The information collected on vehicles, their loads and delivery information from each area now forms the basis for an efficient route planning and vehicle usage system that was not previously available.

2.7.8. Seattle Tacoma Sea Port, USA – intermodal container seals

Company	Application Land and sea logistics
Benefits Sought Cost reduction Increased security	Status Roll–out (Complete)
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Read Only Price: $30.00	Interrogator: Savi Technology System Integrator: Savi Technology
Further Information Savi Technology: www.savi.com	

Report
Major RFID systems, modelled on the US JTAV military system, are now being installed in civilian logistics systems. The largest recent example, initiated in mid 2002, addresses sea containers in the context of the new terrorism.
Over 17,000 sea containers, carrying more than 80 per cent of US imports, arrive daily at US seaports, often located near major cities and industrial centers. The initiative aims to enhance the safety, security and efficiency of cargo containers and their contents moving through the global supply chain into US ports.
Driven and initially funded by industry, this initiative called "Smart and Secure Tradelanes" (SST), is focused on container security and tracking and will be built on existing infrastructure and technologies that are both proven, available for immediate deployment, open and adaptable to enable integration of new "best-of-breed" technologies as they emerge.
The industry-driven SST initiative will demonstrate the principles of the US Customs Container Security Initiative (CSI), Customs-Trade Partners Against Terrorism (C-TPAT), and the US Department of Transportation's Transportation Security Agency's (TSA) maritime security initiative, such as Operation Safe Commerce. Implementation of SST began immediately and was operational by year-end. It involves automated information technology infrastructure linking ports such as Singapore, Rotterdam and Hong Kong with major US ports such as Seattle/Tacoma which is the first domestic port to

rollout.
As in the military, the system improves the tracking and security of shipments coming into the United States through electronic event-driven alerts, anti-tamper systems, virtual inspection and authenticated audit trails. The TAV network is built on existing US and international standards and on the Universal Data Appliance Protocol (UDAP), which allows open "plug and play" integration of automatic data collection devices, such as RFID and GPS, along with sensors, scanning and biometric systems.
"We're all motivated by a desire to make sure world commerce remains secure and free of threats", said Coburn, recently retired four-star general and former Commanding General of the US Army Material Command who was instrumental in implementing the TAV network for the US Department of Defense. "The ports and shippers are demanding realistic solutions that can be tested today and adapted and built upon in the future. This is one solution that's been proven to work and will provide a real-life model that both government and industry can leverage and learn from in order to rapidly build an international system for cargo security".
Integrated system
Savi Technology report that, initially, the SST rapid deployment implementation calls for an integrated security and container security system to register individuals, authorize roles, and to capture tracking a security events throughout the supply chain. Working with shippers, carriers, service providers, foreign and US port terminal operators, containers will be tracked and automatically authenticated from the point of manufacturing, port of loading, transhipment port and to final discharge in the US. SST, which will work in close coordination and consultation with government agencies, will develop and test potential auditable security standards for maintaining secure ports, shipping facilities and container tracking and security.
"This is a model for how our nation can improve port security, and I'm proud that the Northwest is on the cutting edge as the first commercial port in the nation to offer this level of security", said Senator Murray. "Because shippers value safety, security and efficiency, Seattle and Tacoma will become even more attractive to shippers worldwide. The new thinking, new technology and new partnerships at work here will result in a more secure and more efficient chain of commerce. This partnership protects our cargo and our ports, and closes the gap that may leave us vulnerable".
Best in class
Initial port operating companies spearheading Smart and Secure Tradelanes, which together account for 70 per cent of the world's container port operations, are : Hutchison-Whampoa, the world's largest port operating company, managing 30 ports in Asia, Europe, Africa and the Americas, accounting for 40-50 per cent of the total import container traffic in US ports: PSA Corporation, which handles 25 per cent of the world's container transhipment volumes and operates 14 container terminals in nine countries including Singapore, Belgium, Italy, China, India, and South Korea; and, P&O Ports, one of the world leading port operators with 21 container terminals in 19 countries and 84 ports, including terminals in New York, Baltimore, New Orleans and Miami.
Solution providers involved in the SST initiative are Savi Technology, which helped build and operates the US Military Joint Total Asset Visibility network, which is the world's largest active RFID (i.e.. with a battery in the tag for long range operation etc.) tracking system for the US Department of Defense; Sandler, Travis Advisory Services, the international trade consulting firm; Qualcomm, a global leader for mobile fleet management using satellite communications and GPS systems; SAIC, a leading system and technology company for ports and transportation companies, including non-intrusive inspection systems and Parsons Brinckerhoff, one of the largest transportation and infrastructure engineering firms in the world.
Funded by the three port operators, who are also members of the Strategic Council on Security Technology, in Phase One SST will deploy baseline infrastructure, hardware, including electronic seals, sensor devices and sophisticated scanners and web-based software to secure and track containers in near real time.
"PSA Corporation is participating in this project to ensure that we remain on the leading edge of information technologies that can improve the speed, efficiency and security of port operations for the world's carriers and shippers", said Ng Chee Keong, group president for PSA Corporation Ltd.
"The stakes are too high not to take immediate action in using the latest technologies to protect the safety and security of the world's sea ports, through which 90 per cent of world freight moves every day", said John Meredith, group managing director of Hutchison Port Holdings, a subsidiary of Hutchison Whampoa Ltd.
"P&O Ports is pleased to be a key participant in this innovative project, which will undoubtedly help to bring about new standards for supply chain security", said Ned Holmes, Chairman of P&O Ports, North America, Inc. and former Chairman of the Port of Houston Authority.
"The Port of Seattle welcomes the SST initiative", said Mic Dinsmore, Chief Executive Officer, Port of Seattle. "As one of the primary Pacific gateways into the United States, the Port of Seattle must take a leadership role in establishing systems that ensure the safety and security of ocean cargo. SST will make a real difference immediately upon its deployment".

2.7.9. Royal Mail, UK – roll cages

Company Royal Mail UK	Application Land and sea logistics
Benefits Sought Inventory control, System automation, Error prevention	Status Roll–out (Complete) End: May 2003
Tag Supplier: Avonwood Frequency: LF (132 KHz) Format: Active Read/Write Label Range: 1m	Interrogator: Avonwood System Integrator: Avonwood
Further Information Avonwood: www.avonwood.co.uk	

Report

Mail Rail was a train that ran underground in London, carrying letters and parcels for UK postal service Royal Mail. The company used a type of roll cage called "Mini Yorks" on the Mail Rail and sorting offices often found they had either too many Mini Yorks or not enough, causing delays in the system.

Royal Mail chose Avonwood's Eureka 411 RFID tagging system to identify and trace the Mini Yorks. 1300 tags were fixed to the underside of Mini Yorks, and interrogators were installed at every entrance into the lifts used to move mail from the underground to one of four mail centres at Mount Pleasant, Rathbone Place, Paddington and the Eastern Office. The Mini Yorks were then sent up to the relevant mail centre for sorting.

Royal Mail developed their own database for the system, which logged which lift each Mini York entered, at which mail centre, making it easy to track each Mini York and route it back into the system quickly. This significantly improved distribution times and efficiency, since it was no longer necessary for staff to physically search for the Mini Yorks or to telephone other departments to locate and move them.

Rail Mail ceased to run in May 2003.

2.7.10. Parcelforce, UK - postal trailers

Company Parcelforce postal; trailers UK	Application Land and sea logistics
Benefits Sought Cost reduction Speed of response Integrated system	Status Roll–out (Complete)
Tag Supplier: Avonwood Frequency: LF (132 KHz) Format: Active	Interrogator: Avonwood System Integrator: Avonwood
Further Information Avonwood: www.avonwood.co.uk	

Report

Source: Avonwood

Parcelforce Worldwide is the largest parcel carrier in the UK with more than 12,000 staff and 8,000 vehicles. It carries in excess of 135 million parcels a year. Parcelforce staff found that on average, it took 15 minutes to process a vehicle into a depot from the gate to the appropriate loading bay. Now, thanks to a Eureka RFID tagging system from Avonwood Developments, this delay has been reduced to less than one minute.
The system utilises a battery-powered, i.e. active RFID tag in a protected casing this being fitted to a chassis member of each trailer unit. The tag is read by road loops (coils buried in the road) as it enters the site so that when a driver arrives at the depot, information regarding its load, destination, time and date is automatically read into the Parcelforce Information system.

Source: Avonwood

This immediately directs the driver via a screen to the correct loading bay and at the same time notifies the warehouse staff that the trailer is coming.

Source: Avonwood

After the trailer is loaded, a "finish command" is sent to the despatch system stating that the load is ready for collection with instructions for the driver as to where to collect it from and where to take it. There is no delay in completing paperwork, in contrast to the previous system and all documentation is automatically generated, reducing the time lag from the trailer being loaded to the time it is sent out. In conjunction with Parcelforces' fully automated sorting system it offers the benefits of a fully integrated delivery, sorting and despatch system. The quicker Parcelforce can start sorting parcels and the more the loading bays are utilised, the more efficient the system becomes.

2.7.11. Mercator Transportation, USA – intermodal container tracking

Company Mercator Transportation Group USA	Application Land and sea logistics
Benefits Sought Crime prevention, Traceability	Status Trial successfully completed Start: 2004 End: 2004
Tag Supplier: Savi Technology Frequency: UHF (433 MHz) Format: Active Integrated Tamper sensing seal Range: 30 meters Price: $30 Number of Tags:12*	Interrogator: Savi Technology System Integrator: Science Applications International Corporation (SAIC)/Parsons Brinckerhoff
Further Information Savi Technology: www.savi.com *IDTechEx estimate	

Report
In mid 2004, the first 12 Operation Safe Commerce (OSC) intermodal shipping containers arrived at a national retailer's distribution centre south of Seattle, USA. Responsible for this project were Science Applications International Corporation (SAIC) and its team mates, Parsons Brinckerhoff, Savi Technology and Mercator Transportation Group.

OSC is a public-private relationship being implemented by the USA Transportation Security Administration, and is dedicated to finding methods and technologies to help protect commercial maritime shipments from the threat of terrorist attack, illegal immigration and other contraband, while minimising the economic impact on this vital transport system.

The 12 containers travelled through the supply chain from a remote location in Central America, where they were videotaped as they were loaded onto the trucks and then sealed with container seals, to a Pacific coast port. They then arrived at the Port of Seattle and finally were trucked to the distribution centre. The containers were tracked throughout their journey by RFID tags and GPS satellite tracking.

Additional containers will be sent and evaluated throughout 2004.

2.7.12. Lynx Express, UK – roll cages

Company	Application
LYNX Express UK	Land and sea logistics
Benefits Sought	**Status**
No misroutes Cost reduction Improved information Error prevention	
Tag **Frequency:**	**System Integrator:** Trenstar KTP
Microwave (2.45 GHz)	
Format:	
Active	
Further Information	
Trenstar KTP: www.trenstar.com	

Report

LYNX Express is the largest independent express parcel carrier in the UK. It has a new "Superhub" and HQ development at Nuneaton in the UK. This uses RFID tagged roll cages. As a result, LYNX Express' competitive position is stronger than ever, when measured in delivery capacity and use of advanced technology.

By incorporating an intelligent scan using RFID tagging, LYNX Express record where the roll cage is, at what time and whether or not it should be there. This is a major advance on barcodes. The system from Trenstar KTP takes the data, compares it with the LYNX Express host mainframe computer and sends the message back telling the Superhub staff that the roll cage is or is not where it should be. They can react rapidly and appropriately. Doug Haworth, Head of Operations Development at LYNX Express says, "This solution does just that, combining the very latest RFID technology with real-time barcode technology and it is seamlessly integrated with our existing systems". It is helping to cut the cost of misroutes from approximately £100,000 ($160,000) yearly to virtually nil. Because Superhub operators are alerted immediately something goes wrong with the traffic light system, they are able to capture misroutes promptly during the course of the cross-deck operation through the Superhub.

"This new intelligent tracking system offers measurable business benefits including greatly increased levels of efficiency and vastly improved management information", said David Burtenshaw, Chief Executive, LYNX Express.

2.7.13. London Waste, UK – vehicles

Company London Waste vehicles UK	Application Land and sea logistics
Benefits Sought Cost reduction	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active	

Report
London Waste in London, UK, receives around 1 million tons per year of industrial and domestic waste from various companies and London authorities. Half of this is incinerated as fuel in its on-site power station.
Up to 600 trucks deliver to the site everyday. To provide maximum speed of entry, regular and authorised vehicles use fast track entry and exit weighbridges. The trucks are equipped with a tag which incorporates a unique and permanent 8 digit number, mounted on the inside of the windscreen, rather like a tag used for non-stop road tolling. Interrogators are installed at various barrier control points and at the weighbridge. The interrogator passes the tag ID number to the gatehouse computer system. It is verified as valid and the date, time and weight of the vehicle are logged and the barrier is opened automatically whist the driver maintains a normal driving line. All the details f the vehicle, its owner, and invoicing information are combined with the time, date and weight to create an automatic invoice that is processed. The facility is available to the tagged vehicles day and night, when the site operates with minimum staff.

2.7.14. J.A.M Distribution and Cemex, USA – vehicle loading and fuelling

Company J.A.M. Distribution and CEMEX USA	Application Land and sea logistics
Benefits Sought Error prevention, System automation, Improved data capture	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only Card	Interrogator: TagMaster

Report
J.A.M. Distribution is a supplier of chemicals, synthetics and bulk fuels. One of its customers is CEMEX, on of the world's largest cement companies, and J.A.M. and CEMEX wanted a system to control access to the fuel dispensers that service CEMEX's vehicles and records information about each fuelling transaction CEMEX undertakes.

As well as providing accurate information on fuel usage and costs, CEMEX particularly wanted the system to prevent unauthorised access to the pumps and to speed up the fuelling process. Previously, most of the process was manually handled and authorisation was based on personal knowledge by the fuel station's personnel.

Each of CEMEX's vehicles was mounted with an RFID tag, which is read by an interrogator at the fuelling island as the vehicle approaches. The date, time, truck identification number, gallons dispensed and price is captured and transmitted via the Internet to a private intranet website made for J.A.M. Distributing. As the vehicle drives away from the fuel dispenser, the pumps shut off and cannot be accessed again until another appropriately-tagged vehicle arrives.

2.7.15. HiroCem, Slovakia – trucks

Company HirOcem cement plant	Application Land and sea logistics
Benefits Sought System automation, Error prevention, Cost reduction	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read/Write Card Range: Up to 5 meters	Interrogator: TagMaster

Report
The HirOcem cement plant is the largest cement plant in Slovakia, and is in operation 24 hours a day. The cement business is highly competitive and the plant needed to speed up the delivery process for trucks and railcars, unloading coal for its furnaces and loading various qualities of cement. As well as needing to automate the procedures for loading trucks and railcars, the number of large transactions involved meant that the shipping document procedures needed to be automated. Product losses due to the lack of loading and unloading controls also caused concern.

More than 1000 S-1450 Heavy Duty ScriptTags from TagMaster were mounted on cement trucks and railcars, with each tag holding the vehicle's identification number and additional company data. TagMaster's WiseMan 1500 interrogators were installed at the plant's loading points, the entrance and exit gates, and along the railroad tracks. The interrogators along the railroad tracks identify cargo carriages on the trains so that they can be automatically directed to the appropriate delivery points for unloading raw materials or loading the correct quality of cement. Similarly, the interrogators at the entrance gates can direct trucks to the appropriate bay.

2.7.16. DHL and Nokia, UK/ Finland – cases

Company	Application
DHL and Nokia UK/Finland	Land and sea logistics
Benefits Sought	**Status**
Crime reduction	Trials
Tag **Frequency:**	**System Integrator:** TRI-MEX International
UHF (Passive – 13.56 MHz Active – 868 MHz)	
Format: Active and passive tags **Range:** 30-100 meters **Price:** Thirty dollars or so	
Further Information TRI-MEX International: www.tri-mex.com	

Report

As one of eight projects funded by the Chipping of Goods Initiative, TRI-MEX are working with mobile phone manufacturer Nokia and courier DHL to tag consignments of mobile phones that will be followed through their distribution network via TRI-MEX's satellite tracking system. The new system will help them to identify quickly if any part of their cargo is missing, allowing police to react quickly to reported thefts.

Guy Mason, Marketing Director at TRI-MEX International, said:

"TRI-MEX International is delighted to have been selected by the Home Office to develop the use of RFID chips in pursuit of the reduction in crime. The advantages for the UK supply chain and consumers are significant. For every high technology product sold to the consumer, 10 per cent of the cost goes to cover losses through theft; the disruption in manufacturing and transportation are significant, and many of the stolen export products are re-imported into the UK to compete against our own manufacturers."

Andy King of TRI-MEX, UK, told IDTechEx they have completed phase one of the RFID implementation to track consignments of Nokia cellphones on DHL carriers. This is one of the projects of the UK Government's Chipping of Goods Initiative. Active tags (battery boosted tags) are placed on each box of 10 cellphones as they enter the UK through a DHL hub. At this point, 40 foot long trailers take the cellphones to 40 destinations. At the Distribution Centres (DC) these are sorted, then transported to the retailers in smaller transit vans.

The small size and high value of the cellphones makes them a target for theft during these transits, hence the implementation of an RFID system to enable the real time location of these phones at pallet and box level.

As the phones enter the UK hub the tags are attached to the boxes, then read by a Symbol reader which sends the data to a central TRI-MEX database. These data include the content of the box, and its destination. The computer calculates each of the nodes the box will pass through from the hub to arrive at the retailer. Any deviations from this route will be detected within seconds.

Technology

TRI-MEX had looked at the option of using passive tags, but due to the presence of metal in the vans (and in the phones), background noise, high volumes of tags in one space, and the need for a long range, active tags were used. These were Identec i-Q tags, working at UHF (around 868 MHz), offering 100 meters range in perfect conditions and at least 30-40 meters in "noisy" environments. The tags are 4.5 inches long by 1 inch wide. The RFID system built into each transit carrier is linked to a GPS system which enables the real time location monitoring of the phones from TRI-MEX's central database center. Once TRI-MEX overcame "blackspots" in the RF field, 100 per cent read reliability was achieved. The tags also contained temperature sensors which, at set intervals, record the temperature, date and location at that time offering a real time temperature log. The temperature log history can be retrieved at any time online.

Although active tags are more expensive than passive tags, King described that the active tag infrastructure costs was considerably less than passive systems, which would have required many more readers, and hence more complex back end components and systems.

Speed

The whole implementation has taken just over 12 months from concept, and in tests the system alerted the center staff in less than a second when a van pulled over into a lay-by and some phones removed. Of 145 shipments with the tags, 18 were incorrectly loaded onto the wrong trailers at the initial hub, but this was immediately identified and rectified.

Phase 2

The active tag system currently operates only in the UK: TRI-MEX will be extending it back to the point of manufacturer of

the phones, so they are tracked as they come of the production line in Helsinki, Finland, and are transported to the airport. Further, following the successful results of the first phase, TRI-MEX are now planning to tag each cellphone individually. This will consist of a passive tag embedded in each cellphone itself. They have already developed a prototype trailer system, where tags are read on entry and exit off the vehicle to confirm if they have been loaded or are removed. Tags in each phone will also provide numerous other paybacks. For example, Nokia is experiencing problems with people using software to "unlock" the cellphone ID so they cannot be traced when they are stolen. An RFID tag within a cellphone would contain the unique phone ID, and this could not be changed, so the origin of stolen phones can be proved far more easily. They worked with DHL and Escort Memory systems (EMS), and expected to demonstrate the system by February 2003, an impressively fast timescale.
The passive 13.56 MHz tags in the phones have limited range (approximately up to a meter, but less due to metal in the phone), therefore TRI-MEX are planning to use a repeater antenna on the outside of the cellphone box to boost the range further so it can be detected while being loaded and off loaded from the vehicles. This boosts the range to several meters, although the signal is more directional.
The Future
DHL handle about 150 billion items a year. They have a need to tag small and valuable items to reduce theft and improve tracking of these. Following that, the courier expects to tag all 150 billion items by 2005. TRI-MEX are also talking to pharmaceutical companies to track vaccines through the distribution process and monitor their location and temperature in real time.
The Nokia project has been so successful that TRI-MEX are now in the process of commercialising it for other customers. Using a combination of technologies linked together they have formed a hierarchy which enables them a new level of asset visibility as shown in table 1.

Table 1 Nokia and DHL nest technologies to provide real-time product visibility

	Technology type	Object identified
Increasing technology cost ↑	GPS	Real time location (vehicle)
	Active tags (RFID)	Short range real time location(cellphone box)
	Passive tags (RFID)	Identification of each product (each cellphone)

Source : Nokia

2.7.17. Intermodal Cargo Shipments

Company	Application
	Land and sea logistics
Benefits Sought	Status
Cost reduction/Security	Roll-out (Ongoing)
Tag	
Supplier:	Interrogator:
Savi Technology	Savi Technology
Format:	System Integrator:
Active	Savi Technology
Read Only	
Further Information: Savi Technology: www.savi.com	

Report
Similar to air cargo, intermodal cargo shipments typically have a hierarchical structure of items within containers. A common hierarchy includes boxes and cartons loaded on pallets, pallets loaded into intermodal containers, and intermodal containers loaded on chassis, rail cars, and ships. The pallets are often loaded with boxes, cartons and other items as part of an orderly build-up process within a factory or warehouse, making Passive RFID an appropriate fit in many situations. Once loaded, tracking of the pallets may require either Passive or Active RFID, depending on the particular situation.
In some cases, pallets move through dedicated portals or dock doors, one or two at a time, and there is no need to

monitor their location and status at other times. In other cases, the movement of pallets is more dynamic, within open yards and facilities, and there may be a need to continuously monitor their presence, not just at dock doors or other specific read points. Passive RFID is appropriate for the former, Active RFID for the latter.
At the intermodal container level, security is once again a concern, especially as the US and other countries push cargo inspections back to the point of origin and require highly reliable validation of the container integrity at the destination. There may also be the need for roadside monitoring of container movement, and for continuous monitoring of containers within ports, terminals, and other large facilities. Active RFID, therefore, is the right selection at the container level. For chassis, rail cars, ships, and other conveyances, the appropriate technology may be Active RFID or a combination of Active RFID with GPS-enabled wide-area monitoring. With this latter combination, the ability to track in-transit container movements (via GPS) can be combined with continuous monitoring of an Active RFID security seal on the container, providing a highly reliable cargo monitoring and security solution. See table 1.

Table 1 Typical RFID requirements for intermodal cargo

Item	Characteristics	Technology
Boxes Cartons Individual Items	Structured, orderly process for loading - dedicated loading stations, conveyors.	Passive RFID Barcode
Pallet	Structured or unstructured movement depending on situation.	Passive RFID or Active RFID
Intermodal container	Security requirements. Area monitoring within ports, terminals. Roadside requirements.	Active RFID
Chassis, rail car, other conveyance	Area monitoring within ports, terminals. Roadside requirements. Intransit visibility.	Active RFID GPS (wide area)

Source: Savi Technology

2.7.18. Carlisle Carriers, USA – tractors and trailers

Company Carlisle Carriers USA	Application Land and sea logistics
Benefits Sought Error prevention, System automation, Cost reduction	Status Roll–out (Complete)
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only Card Range: Up to 5 meters	Interrogator: TagMaster

Report
Trucking firm Carlisle Carriers was looking for an accurate yard inventory system that would give it a high level of security and would also provide a more accurate method of matching tractors to trailers. Previously around 3% of tractors and trailers were mismatched, leading to around $18 million in losses every year.

The company chose an RFID system from TagMaster that deals with both entry control and matching trailers and tractors. Interrogators were installed at the entrances and exits of the yard and the company's 350 trailers and 150 tractors were fitted with RFID tags.

The gates will now only open for authorised, tagged vehicles and only if the correct trailer/tractor combination is attempting to go through. The interrogator at the gate records the tag's ID number and the time and date or entry or exit and this information is stored on a central database, which also handles matching of trailers and tractors.

2.7.19. Alliant Atlantic Food, USA – access control

Company Alliant Atlantic Food USA	Application Land and sea logistics
Benefits Sought System automation, Cost reduction, Error prevention, Improved data capture	Status Roll–out (Complete) Start: 1998
Tag Supplier: TagMaster Frequency: Microwave (2.45 GHz) Format: Active Read Only	Interrogator: TagMaster

Report
Alliant Atlantic Food Inc. distributes frozen and dried food products to restaurants 24 hours a day, 365 days a year, from its 34 depots across the US. The company's Manassas depot is a 400,000 square-foot warehouse with 31 loading and unloading doors. The company has 150 of its own vehicles at the depot, and the preparation for departures of these trucks and trailers is mostly done during the night and finished by 5:00 am.

Since the depot is open 24 hours a day, the company wanted an access solution that did not have to be manned by staff. In 1998 the company chose an RFID system, which was provided by TagMaster of Sweden to manage access control for the depot. The RFID-based system assists in automatic data capture at the gate, works as a planning and administrative tool and provides the company with statistics that would enables it to measure productivity and make plans for future improvements.

Two interrogators have been mounted at the gates of the depot and each of the company's vehicles has been fitted with a TagMaster S1455 MarkTag. The system allows Alliant Food to register its trucks as they arrive and leave the depot and compile any required reports without any human intervention.

2.7.20. Somerfield Supermarkets, UK – trucks

Company Somerfield Supermarkets UK	Application Retail/CPG
Benefits Sought	Status Roll–out (Complete)
Tag Frequency: UHF (433 MHz) Format: Active Read Only	System Integrator: Trenstar KTP
Further Information Trenstar KTP: www.trenstar.com	

Report

The need

Somerfield Supermarkets, the UK based supermarket chain, wanted to improve tracking and security checking of its vehicles at two distribution centres. Previously, security personnel had to check the computer in the gatehouse, write down ID numbers for the cab, trailer and seal on pieces of paper, then had to walk outside and check the numbers. They often had to return to the gatehouse to input data into the system and check again before allowing the driver to enter or leave. Manual input of data was time consuming (typically 2 - 3 minutes) prone to error and it caused traffic to build-up. The new system permits the operation to be carried out within five seconds.

Technology

The application uses active tags to identify the cabs and trailers. When the cab and trailer are allocated to a route and driver at the warehouse, the information is entered into the host system. The trailer is fitted with a sealing unit that displays a random number when loading is complete. This is input into the system so security checks can be made throughout the journey. Handheld interrogators detect the tags and communicate with the host system using RF LAN. This permits gatehouse personnel to log vehicles in and out automatically and execute real-time checks of information. KTP achieves read ranges of over one meter. Installing fixed readers to detect the tagged vehicles at distances of five to eight meters is feasible. This will allow vehicles to be automatically tracked in and out of unmanned sites.

Gatehouse personnel now carry out extra duties. Manual inputting errors have been virtually eliminated. Traffic built-up in and out of the gatehouse has been reduced; this allows goods to reach stores more quickly. Fixed interrogators at strategic detection points throughout the UK permit the cabs and trailers to be tracked and real-time information can be made available.

Security checking is enhanced. The seal number is automatically displayed on the handheld terminal as well as the seal unit. The seal number changes every time the trailer door is opened for loading or unloading. If seal numbers do not match, the consignment is to be checked to ensure it is correct.

Data is now created automatically on the performance of the personnel. Significant cost savings will be made as the system is rolled-out and return on investment should be achieved over a relatively short period.

2.7.21. Argos, UK – conveyances

Company Argos UK	Application Retail/CPG
Benefits Sought Crime reduction	Status Trial successfully completed
Tag Format: Passive tag on tote boxes active tag on roll cages	

Report
Argos is UK's largest catalogue retailer and stock a large range of high value goods (jewellery, electricals, furniture etc). They are the UK's second largest jewellery seller, and because jewellery is small and high value it (or more precisely its conveyances in the first instance) was an obvious product to start tagging for supply chain visibility. Objectives for their RFID trial as one of The Chipping of Goods project, which is planned over 19 months and aimed at reducing shrinkage on their jewellery products in 12 stores and three Distribution Centres, are as follows:
Develop RFID-based system for tracking returnable "tote boxes" & roll-cages linked to product orders.
Demonstrate shrinkage benefits internal & external.
Assess additional operational benefits for Argos Retail Group and parent company (GUS)
To enable item visibility RFID technologies are again nested at each level in the supply chain. Active RFID tags are used on roll cages, and passive ones on each tote. Jewellery is loaded into the totes, which are then placed on the roll cages and sealed. These are put on trailers and the tags recorded as they are loaded and off loaded from these, so their movements are tracked.
Additional paybacks
Each time the data is read a time history is also recorded, and with the information they have been able to identify delays in their supply chain. Some distributors who have claimed faster throughout times than what was actually achieved were identified and the issues resolved.
Argos are planning a new warehousing hub, and based on the initial success of this trial IDTechEx was told by the Chipping of Goods Office that they are likely to implement a full system there.

2.7.22. Paramount Farms, USA – farming vehicles

Company Paramount Farms USA	Application Manufacturing
Benefits Sought Cost reduction, Speed, Improved data capture	Status Roll–out (Complete)
Tag Supplier: Intermec	Interrogator: Intermec System Integrator: Intermec
Further Information Intermec: www.intermec.com	

Report
Paramount Farms is the world's largest supplier of almonds and pistachio nuts, selling to more than 20 countries. "The big challenge with a pistachio harvest is that once it starts, there's no way to stop it," said Dave Szeflin, Paramount's vice president of operations. "In our average harvest season, incoming green product totals a half billion pounds over a six-week period. Given this time constraint, as we increase our production goals, our efficiency and productivity must likewise increase."

An RFID system provided by Intermec Technologies Corp. helped Paramount to cut initiation time for processing new crop loads by 60 percent, meaning the company did not need to go ahead with plans to enlarge its scale house.

The system uses eleven handheld computers, three access points and three fixed RFID tag readers.

As each trailer arrives at Paramount's scale house, its RFID tag is interrogated by a fixed reader. The reader captures each radio-frequency tag's unique identification number and wirelessly transmits it to the central database. The database then relays the pre-recorded profile of the identified trailer back to the scale house worker's handheld computers, giving the worker information on the trailer's net weight, license plate number, equipment number and owner name.

Scale house workers next use the handheld computers to gather load details and send them to the database. The grower name, ranch, field, product temperature and harvest method is selected from pull-down lists on the computer. The trailer's gross weight is automatically retrieved from the truck weigh scale and a weight certification is printed.

As trucks begin to arrive at the processing facility, workers prioritize their entry based on whether the truck is from a grower partner (granting them priority over Paramount trucks) and the temperature of the load. Turn time (the duration of time it takes from receiving a load to the time it is processed) is a key metric that gets entered into the 710 and reported to grower partners.

2.7.23. Meat producer, Canada – case monitoring

Company Meat monitoring Canada	Application Land and sea logistics
Benefits Sought Safety Error prevention	Status Roll–out (Complete)
Tag Supplier: KSW Microtech Frequency: HF (13.56 MHz) Format: Active Label	Interrogator: KSW Microtech System Integrator: Syscan International
Further Information KSW Microtech: www.ksw-microtec.de	

Report
KSW Microtec AG was founded in November 1994 by Dr Thomas Seidowski, who left university teaching and research to create an electronic packaging start-up.
Seidowski grew the company organically rather than using venture funds into a thriving and profitable world-class smart and active RFID solution provider. While relying on products such as passive inlays to make KSW profitable, Thomas decided to create an extension to RFID, namely sensory/RFID hybrid inlay, VarioSense, targeted at environmentally sensitive products such as food, pharmaceuticals, and blood.
The new facility includes a 4,000 sq meter clean room facility consisting of:
Wafer services laboratories including Proprietary Palladium bumping technology.
Inlay assembly lines with capacity of 100 million inlays a year.
Proprietary TempSense label assembly line.
Printing presses for Power Paper battery manufacturing and RFID antenna printing.
A state-of-the-art electronic packaging R&D facility.
KSW Microtec of Germany can produce 50 million electronic smart labels yearly, with a wide variety of diagnostic capabilities in addition to RFID. It has had success with a two dollar label for time-temperature monitoring of blood, vaccines and food. A typical credit card sized label including laminar paper battery is shown in figure 1 with the specification in table 1 and an example of an operational mode in figure 2

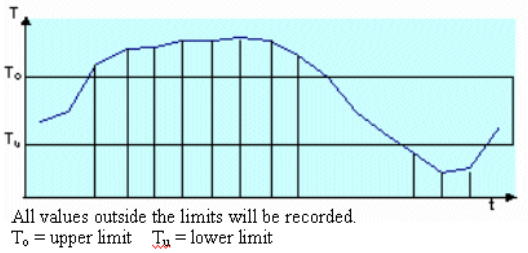
Figure 1 The TempSense active label which is the size of a credit card but thinner

Table 1 TempSense active label specifications

Parameter	Specification range
Operating frequency	13,56 MHz
Chip serial number	Unique
Data memory	2 - 8 bits
Communication protocol	ISO 15693 compatible
Anti-collision	› 30 labels
Operating temperature	-20°C to +50°C
Measuring interval	Programmable
Thresholds	2 programmable
Battery type	paper-thin, environmentally friendly
Battery live time	1 to 5 years depending on application

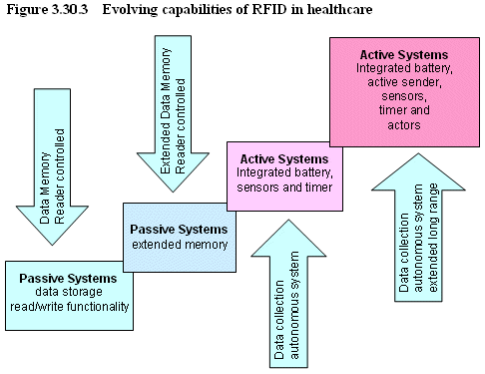
Source: KSW Microtec

Figure 2 TempSense - operation modes



It sees a wide variety of capabilities in future as shown in figure 3 where MEMS refers to Micro Machined Electromechanical Systems, currently a hot topic in sensing and actuators.

Figure 3 Evolving capabilities of RFID in healthcare



The present and future technology drivers for electronic sensors and RFID are seen as:
Microscale sensors
- MEMS based
- Digital/analog ASIC based
- Biological/ASIC hybrid
RFID
- Simple design
- Low-cost manufacturing
Power
- Low-cost and printable
Eitan Avni, director of business development, tells us that the needs for electronic diagnostics using labels include:
Temperature
Time
Temperature-time (TTI)
Pressure
Ultraviolet dose/light
Humidity
Chemicals including gases
Sterilization - Gamma ray, steam, UV, Ethylene oxide
Virus
Bacteria
Shock
Vibration
Tilt
Lab-on-chip.
He sees the paybacks as including safety, security, convenience and brand protection and enhancement.
Avni also says gives a detailed example being the case of temperature enabled packaging allowing detailed tracking of product/package temperature as it moves through the supply chain. Here, automated temperature tracking at the pack level brings many benefits including:
Reduced product wastage
Improved labour savings
Reduced disputes with distributors and retailers
Improved customer satisfaction
Greater understanding of supply chain dynamics.
We could add that electronically time-referenced parameter logging can even provide acceptable evidence in court if, say, a trucker has damaged goods. This is not usually possible with labels based on responsive inks because the data are less reliable and less specific.
Canadian meat producer trials KSW Microtec tag
Syscan International has developed a time temperature tracking system that a meat producer in Canada began trialling in mid 2003. This TempaSure system consists of Syscan's reader that plugs into handheld devices, laptops and personal organisers, and a database software package designed by the company that logs the time and temperature history of a case or pallet of goods. KSW Microtec has supplied its TempSense time temperature integrator (TTI) labels that incorporate RFID technology.
The tags are placed in pallets of meat initially in shipments travelling interstate in Canada and the US, usually lasting a day or so. Most of the trials are now focusing on long distance shipments, such as Canada to Japan, which can take up to five days. The objective it that meat, mainly pork, reaches consumers in the best possible condition. The company already uses a system, devised by Syscan that embeds RFID transponders in to meat hooks to track meat moving through a slaughterhouse.
Axel Striefler, Syscan's president declared "TempSense can be modified for application for monitoring perishable goods such as pharmaceuticals, cut flowers, vaccines, seafood, fruit and vegetables."

2.8. Case studies of active RFID in Retail

2.8.1. Selfridges, UK – food containers

Company Selfridges UK	Application Land and sea logistics
Benefits Sought Inventory control, System automation, Improved data capture	Status Trial (Ongoing) Start: 2003
Tag Supplier: Wavetrend Technologies Format: Active	System Integrator: Exel

Report
In late 2003, leading UK department store Selfridges began trialling RFID tags to track the stock movements of food brands in its department stores.

The company is using active tags from Wavetrend Technologies to track the movements of 20 vehicles and 120 temperature-controlled food containers from its Hams Hall national distribution centre in the West Midlands to the loading bays of its Manchester, London and Birmingham stores. On arrival at one of the stores, an interrogator on the loading bay door will read the tags that are mounted on each pallet of goods and automatically update Selfridges' stock management system with details of the produce on that pallet.

Exel has also designed interactive touch screen kiosks for the loading bays in each of the stores and at the distribution centre. These kiosks link to the loading bay RFID interrogators and confirm to staff that all the stock has arrived.

With outbound stock, the kiosk loads information onto the vehicle so that stock levels can be cross-checked when it arrives at the next destination.

Exel also hopes to extend the trial to improve stock visibility, increase security and track dispatch and delivery processes within Selfridges' stores.

2.8.2. Safeway Supermarkets, UK – trolleys

Company Safeway Supermarkets UK	Application Retail/CPG
Benefits Sought Prevents "walk outs" of full trolleys without paying	Status Trials
Tag Supplier: Active RF Frequency: Multiple frequencies Format: Trolley handle. AA batteries	System Interrogator: Active RF System Integrator: Active RF

Report
This system sensed if the tag had been through the checkout and the goods paid for and, if not, applied a brake on exit. Trials were successfully completed by Active RF and orders were received for 20 stores but the company folded. US company Gatekeeper is continuing the work.

Press release Nov 2003:

American company Gatekeeper Systems, a provider of retail loss-prevention-technology solutions, has acquired activeRF, of Swaffham Bulbeck, near Cambridge, eastern England.

Located in Irvine, California, Gatekeeper Systems' front end loss prevention solutions, based on a single, integrated technology platform, include a patented shopping cart (trolley) containment system.

ActiveRF is a developer of RFID (radio frequency ID), real time, tracking and locating systems, designed, for example, to prevent the theft of shopping trolleys from the retail premises of customers such as the supermarket chains Safeway and Tesco.

Michael Lawler, president and CEO of Gatekeeper Systems, said: "The acquisition allows us to add new dimensions to our technology. We are confident this move will enhance our offerings in a variety of market niches."

2.9. Other

2.9.1. HM Prison Service, UK – keys

Company HM Prison Service UK	Application Financial and security
Benefits Sought Crime prevention, Cost reduction	Status Roll-out (Ongoing)
Tag Supplier: Avonwood Frequency: LF (132KHz) Format: Active Read/Write: Card Range:1 meter	System Interrogator: Avonwood System Integrator: Avonwood
Further Information: Avonwood: www.avonwood.co.uk	

Report

HM Prison Service in the UK is using RFID technology to prevent the accidental removal of staff keys from secured areas. Preventing keys from being removed in this way is not only a major security benefit, it also means that the need to replace expensive locks is removed.

The RFID solution was provided by Avonwood. An Avonwood "Eureka 411" active tag is placed onto each set of keys, and interrogators are fitted at each door of secured areas. These interrogators trigger an alarm if the keys are removed.

2.9.2. Delta Downs Racetrack and Casino, USA – keys

Company Delta Downs Racetrack and Casino USA	Application Financial and security
Benefits Sought Legislation compliance	Status Roll-out (Ongoing) Start: 2004
Tag Supplier: Axcess Inc. Frequency: UHF (433 MHz) Format: Active Read/Write Button Range: 30m	System Interrogator: Axcess Inc. System Integrator: Axcess Inc.

Report
Delta Downs Racetrack and Casino is a gaming facility that features a horse racing track, dining facilities, and around 1500 slot machines. If the slot machine keys got lost, then by state law the company must cease its slot machine operations.

In 2004 the company implemented Axcess ActiveTag RFID technology in an effort to prevent this state-ordered closure. RFID tags are attached to the slot machine keys and are identified at doorways to prevent them from being removed from the casino.

Axcess ActiveTag RFID employs small, battery-powered tags that, when automatically activated at control points throughout a site, transmit a wireless message typically 30 to 100 feet to palm-sized receivers networked to the existing corporate network. Tag identification and location information is instantly forwarded to a host computer and the system can dynamically track assets around a building to monitor their whereabouts, detect theft and prevent loss.

3. Components of an active RFID system

RFID systems comprise the following components:

3.1. The tag

Chip tags consist of a microchip and a coupling element – an antenna. Most tags are only activated when they are within the interrogation zone of the interrogator; outside they "sleep". All RFID tags can be both read-only (programmed during manufacture) or, at higher complexity and cost, read-write, or both. Chip tags contain memory. The size of the tag depends on the size of the antenna, which increases with range of tag and decreases with frequency up to a few hundred megahertz, when it has to be a different shape.

3.2. The interrogator

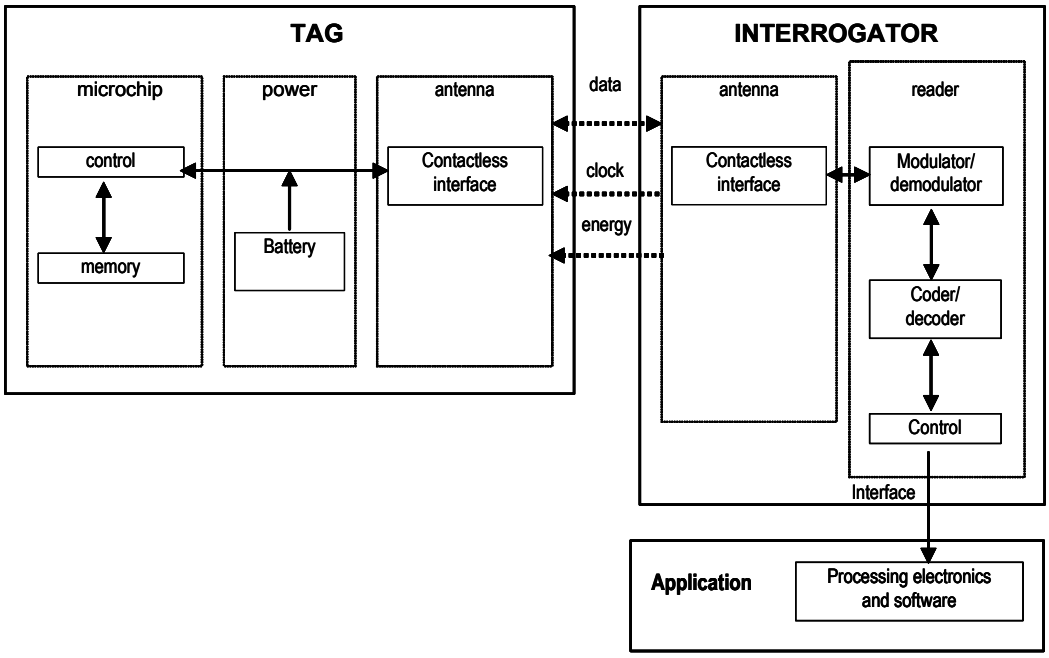
Depending on the application and technology used, some interrogators not only read, but also remotely write to, the tags. For the majority of low cost tags (tags without batteries), the power to activate the tag microchip is supplied by the reader through the tag antenna when the tag is in the interrogation zone of the reader, as is the timing pulse – these are known as passive tags. Active tags may also work in this way ("semi-passive") or may initiate a signal or amplify and retransmit one.

3.3. Other system components.

Other system components typically include back-end electronic hardware and software. Readers and read-writers are fitted with an interface (usually standard interfaces such as RS 232, RS 485,

etc.) to enable the data they receive and transmit to be forwarded to an application system, such as a database, network, or the internet. Figure 3.1 shows the basic operation of an active RFID system whether semi passive, semi active or fully active.

Fig. 3.1 **Basic operation of an active RFID system**



Source: IDTechEx

To be more precise, semi passive tag is energised by a time-varying electromagnetic radio frequency (RF) wave that is transmitted by the interrogator. This RF signal is called a carrier signal. When the RF field passes through to an antenna, an AC voltage is induced across it, which is then rectified to provide power for the tag.

3.4. Multi-tag reading (anti-collision)

With the basic electronics for interrogation, only one tag may be in the interrogation zone at a time, or responses will overlap, confusing the reader. Schemes are also available which allow for multiple tags in the interrogation zone. They can all be read in a very short time without confusion – sometimes up to 1000 at a time. This is "anti-collision software". Standardised methodologies are emerging for all chip tags, - an advantage over chipless tags, where anti-collision capability is primitive or non-existent. Anti-collision capability can reside in hardware rather than software in certain cases.

For applications demanding many tags, tags will need to be read quickly, and if billions of tags are being used every year it must be assumed that there will be more than one tag within the interrogatory zone of a reader at some time in most of these applications. It must distinguish and read tags from multiple suppliers, and be clever enough to 'ignore' tags within the interrogatory zone that should not be there. This technology is readily available today.

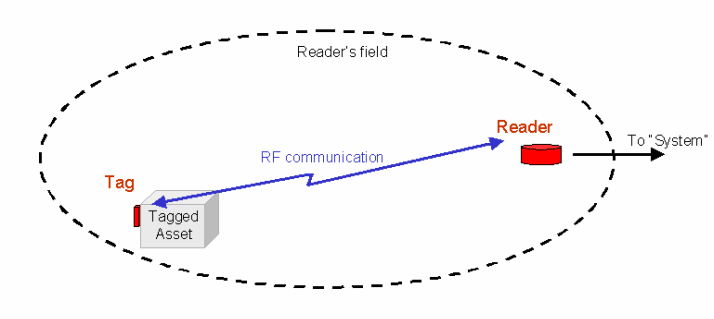
3.5. Choices of physical configuration of active RFID systems

Figures 3.2 through 3.6 and 3.8 illustrate increasingly sophisticated physical configurations that can be employed with active RFID systems.

3.5.1. RFID – basic operation

In the simplest case, the reader sends out a radio-frequency (RF) signal. A tag in the range of this signal responds by reflecting or transmitting its ID to the reader. The reader then forwards collected tag IDs to the "system", providing a required function such as asset identification. Figure 3.2 shows this basic configuration.

Fig. 3.2 **RFID – basic operation**



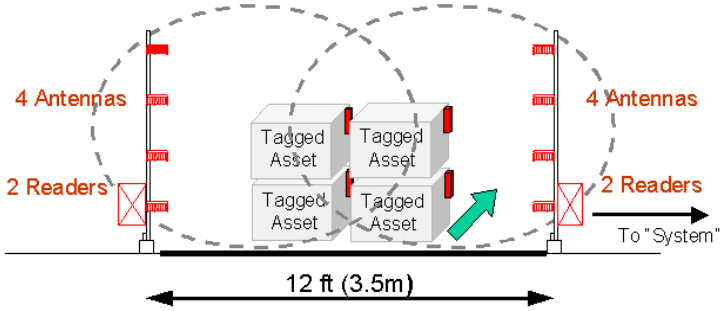
Source: Savi Technology

3.5.2. One at a time or many at a time

Semi passive RFID systems – those with a battery in the tag that is not used to enhance range – usually have up to one meter range (3.5m in some jurisdictions), though some are now achieving 10 meters in ideal conditions. It is not usually possible to write to semi passive tags at more than one meter. Despite this short range, there is still a choice of reading one at a time or many at a time "multitag reading" using "anticollision" i.e. "anti contention" software. Aircraft cargo doors may sense what comes and goes in this way, for example. With one at a time, a short range can be a positive advantage as it avoids nearby items being spuriously read. Multiple tag reading is shown in

figure 3.3. It is also achieved with some semi active and fully active systems. In most cases, tags that are multiply read are also singly read at some other stage during their operation.

Fig. 3.3 **Short range semi- passive tags**



Source: Savi Technology

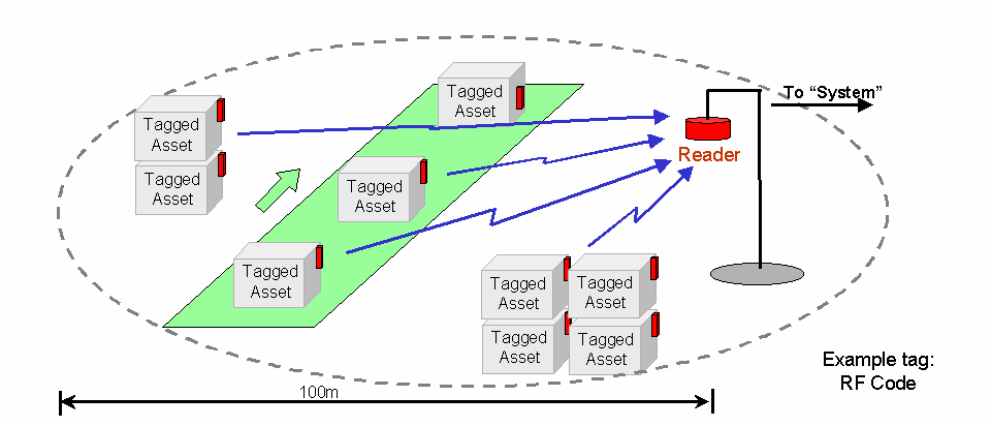
Unfortunately, the time taken to interrogate multiple tags increases with the number of tags to collect, reducing the allowed speed of assets passing through and/or the number sensed in the field at one time. When a battery is used in the tag at this range one can enhance the multitag reading capability and provide extra functionality. For instance, such tags may have data changed at a distance of several meters ("written to") to record what happened to them.

3.5.3. Active beacon tags – long range

Long range physical configuration, as in figure 3.4, is typically 50 to 100 meters, though some companies claim to achieve of the order of one kilometer. (i-Ray Technologies claimed several kilometres but it is no longer in business. Start up Telegesis is now delivering systems that work at 700 meters and it has mentioned capability for several kilometers) A battery is always needed in the tag to achieve these ranges. Usually, it is not possible to write to the tag at these long ranges.

Even with a battery in the tag, there can be limitations to multitag reading. One way around the limitation to multitag reading is the Signpost system of Savi Technology described in section 3.5.4.

Fig. 3.4 **Active beacon tags – long range**



Source: Savi Technology

Chokepoint implementation is difficult or impossible at these ranges. For instance, assets on a conveyor belt cannot be distinguished from assets sitting in storage. The applications are therefore limited to scenarios of continuous tag collection, such as:

- Inventory (interrogate all tags without knowing position) i.e. "area monitoring".
- Search for a specific tag, as with the WhereCall tag of WhereNet where the tag has an alert button. Alternatively, a handheld reader may search for a tag identified as being an area.

The location of the tag is known only in the crudest of terms of within the wide envelope of range.

3.5.4. Signpost system for long range active tag configurations

As we noted earlier, long range means that a vast number of tags may be in range at any one time and the system may wish to interrogate one or only a few of them. Even if it wishes to interrogate all of them, this may be impossible in one go because the multitag reading capability may not be sufficient (e.g. too slow or too few) or such a system is prohibitively expensive, so the work must be done in easy bites. One approach to this that is the most used at present is the Savi technology EchoPoint system where a short range interrogator "wakes up " tags passing nearby and makes them signal at long range to the master interrogator as shown in figures 3.5 and 3.6.

Fig. 3.5 **Antenna hierarchy of Savi EchoPoint active RFID system**

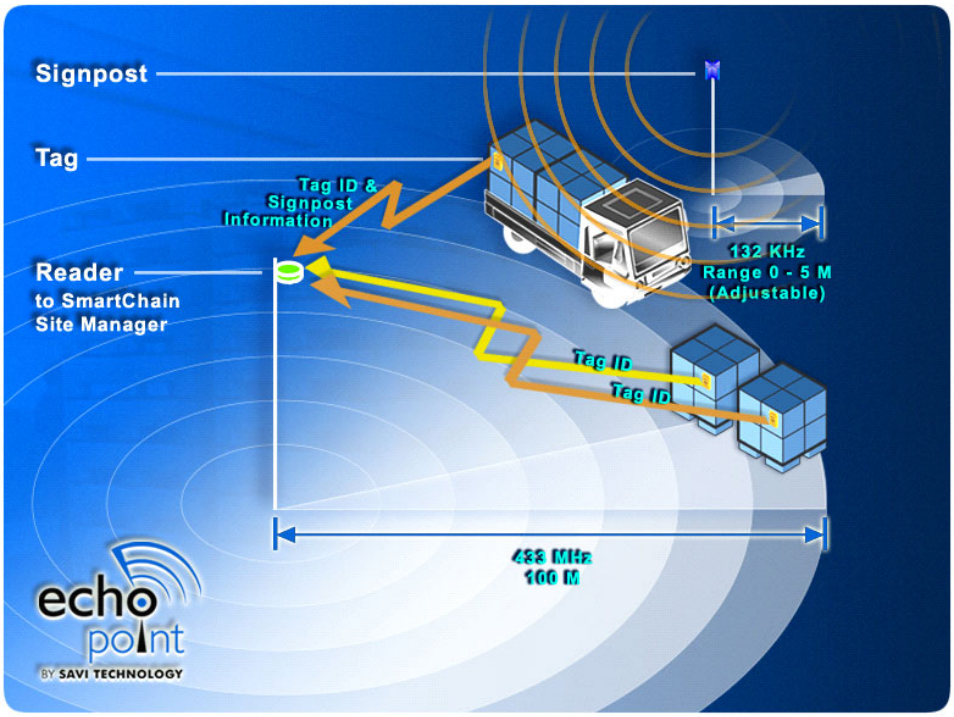


Fig. 3.6 **Savi EchoPoint active tag**

Source Savi Technology

Antenna hierarchy of Savi EchoPoint TAV system

- Signpost transmits a Signpost ID to the tag. Tag transmits both its tag ID and the Signpost ID to the Interrogator (reader).
- Tag ID tells the reader the tag is in reader range, while Signpost ID tells the reader the tag is in the range of that Signpost.

For optimal performance, the Savi Signpost uses 132 MHz at data capture, but the tag uses 433 MHz to transmit to the reader (interrogator) because it diffracts around large objects at the longer distance.

Figure 3.7 shows various active tags from Axcess Technologies. In this case, 126 KHz wakeup is used and 315 MHz transmit. The beacon tag monitors the position of actively tagged vehicles/ items at predetermined intervals.

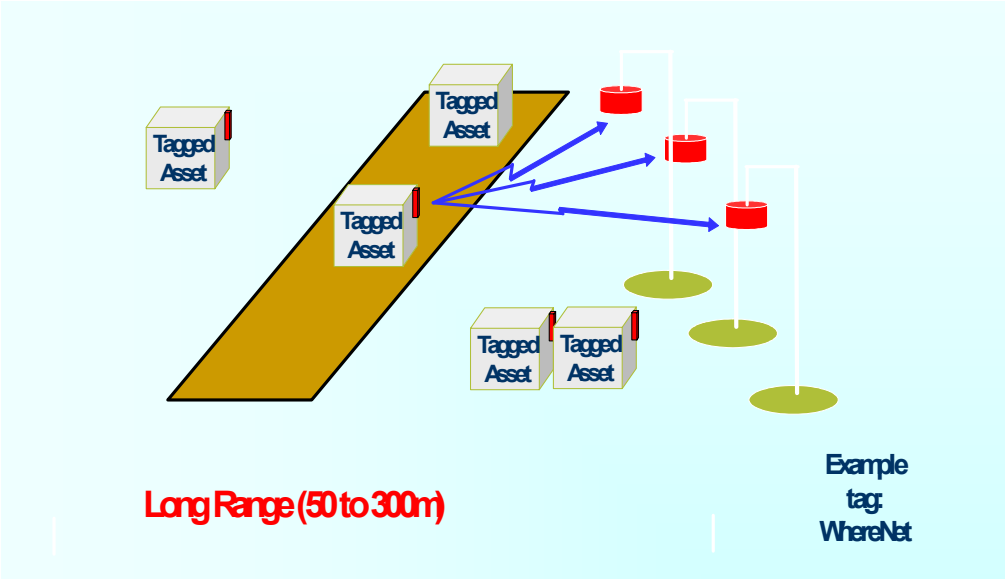
Fig. 3.7 **Various semi-active tags from Axcess Technologies**

Source: Axcess Technologies

3.5.5. Real-time locating systems – long range

Real-time locating systems act in 2D or 3D to locate assets typically at up to 300 meters by triangulation of interrogator beams. Accuracy can be about 3 meters. An active tag is essential to achieve this range and it may be operated in semi-active or fully active mode. However, iRay Technologies claimed 20 meters accuracy at 1 kilometer with an active tag and 0.5 meters accuracy at 30 meters with a passive tag (few others try to use passive tags beyond 10 meters). Figure 3.8 shows the triangulation system employed by WhereNet and others.

Fig. 3.8 **Real-time locating systems – long range triangulation**



Source: IDTechEx

However:

- Resolution decreases in crowded environments
- It is difficult to translate to logical location (e.g.. a specific parking slot).
- There is no ability to write to tags at these distances.
- Expensive infrastructure and software is involved (many readers, expensive processing equipment).
- The only way of generating the necessary beams is to use UHF at around 900 MHz or higher frequencies. The favoured frequency is 2.45GHz. These high frequencies have limitations at present and challenges as discussed in section 4.4.6.

This comes at a cost, and, at more than 15 meters range the tags are much larger than a credit card. At 100-300 meters range they can be the size of a videotape. However, a number of companies and universities are currently developing location systems not based on triangulation but by use of a single beam and, if successful, this will be a lower cost option and the tag may be smaller.

3.6. Options on range

The choices of range are illustrated in table 3.1.

Table 3.1 **Summary of today's RFID physical configurations**

TECHNOLOGY	SOME OF THE ADVANTAGES	SOME OF THE DISADVANTAGES	EXAMPLES OF APPLICATIONS
Very short range. Typically 125-130 KHz or 13.56 MHz	Low-cost tag. Global approval. Tolerant of metal.	Range usually under 2 meters.	Parts in manufacture. Usually an active tag is not needed unless a great deal of data/sensors are handled or environment is very noisy
Active beacon. Typically 433 MHz, UHF or 2.56 GHz for the long range and around 130 MHz for beacon	Moderate cost active. Wide area monitoring. Almost global approval.	Limited chokepoint/portal capability. No means of disabling beacon (air cargo).	Warehouse management. (Savi EchoPoint)
Two-way active. Typically 433 MHz or UHF.	Highly reliable communication. Support for advanced functionality (memory, sensors).	Expensive tag. Limited chokepoint/portal capability.	Exception monitoring of chilled food in transit. (Identec)
Real-time location systems (RTLS). Typically UHF.	Physical finding / locating. Wide area monitoring.	Very expensive infrastructure. Precision does not support "logical" locating (e.g.. specific parking slot). Accuracy may be 20m in 1km	Locating cars in factory car lots, military ordnance and defibrillators in hospitals. (WhereNet)

Source: Savi Technology, IDTechEx

3.7. Systems aspects

Let us now consider the systems aspects of implementing a scheme involving large numbers of "electronic number plates" or more sophisticated operator-independent devices. At the outset, a number of choices have to be made which have fundamental implications for the workings, economics, risks and potential revenues of the scheme. These choices are whether:

- The system is stand alone or networked.
- Associated data are on the device or the network.
- Security is primarily on the device or the network.
- The tag has processing ability or it resides wholly in the network.
- The environment is closed or open to many service providers.

Each of these decisions is covered in this chapter as well as other systems aspects. However, at the outset, we must note that many are not mutually exclusive but a matter of degree.

3.7.1. Network vs stand alone

The economics and practicalities of real world situations mean that there is a continuum of choice as shown in table 3.2.

Table 3.2 **The spectrum of choice between stand alone and networked RFID systems**

STAND ALONE		NETWORKED	
Not polled	Polled	Polled	On-line

Source: IDTechEx

3.7.2. Stand alone – not polled

A product or person may be unmonitored for a variety of reasons. It may be uneconomic, as with very low cost or very small. However, there may be practical reasons.

3.7.3. Polled data

Various technologies are available that can allow data to be captured from the interrogators by authorised route men.

3.7.4. Networked – on-line

Alternatively, on-line intelligent networks can exchange data in real time. This may be more expensive but is more versatile and more secure. Choice between the options partly depends on what is there already. Operation of any system may be in real time or in packets of data at intervals.

These choices are not necessarily exclusive. Systems for secure access, product tracing etc. within, say a theme park could be partly on-line and partly off-line for both practical and economic reasons. Indeed, such a hybrid system is not cast in stone either. It may become more or less networked as the years go by for various practical and economic reasons, so flexibility and upgradeability are issues with most systems.

3.8. Networking at tag, reader or system level

Active tags can be made to talk electronically to each other and interrogate passive tags but only if they have transmitter-receivers that are relatively expensive. For the next few years and probably longer, such tags will be impractical for most of the envisaged applications. A second choice is that interrogators can talk electronically to each other.

Finally, all communication may be back through the network, the readers being dumb and of lowest cost. This is particularly appropriate where much data processing is required or where a large number of interrogators are needed in a given application (e.g.. for near-real-time response) and interrogator cost is therefore very critical.

3.9. Data on the device or network

There is much emotion in industry about choices of data on an artefact such as a tag vs data on the network, or associated computer system. In reality there is usually a choice and both solutions are frequently seen operating successfully.

In general, there is a spectrum of choice in table 3.3.

Table 3.3 **The spectrum of choice between basic number plate tags and those with high data retention**

IDENTIFICATION-ONLY "NUMBER PLATES"		TAGS WITH EXTRA DATA	
Sequential numbers	Segmented sequential numbers	Without processing	With processing

Source: IDTechEx

Arguments for data on the tag

Some active tags such as some of those used for road tolling have read only ability and nothing else. However, most are read write. A similar situation has existed with passive tags. However, many experts to argue that read-write capability should not be lightly abandoned because the network is not always available, particularly when it involves the internet, and some redundancy of information (on tag and in system) is useful in covering for breakdowns (though a threat to data synchronisation). Above all they argue that local caching of data is a reality and a necessity, even if tag price is higher. A read-write chip typically costs double the price of a read only chip, but active tags are rarely more than 20% of total cost system ownership.

Local caching not on the tag

However, Chris Hook of UCC points out that, even with a Write Once Read Many times (WORM) tag, which carries nothing more than a licence plate number, it is practical to have local caching of data which it is anticipated will be required to perform business processes on detection of the arrival of the licence plate codes. This is exactly how a retail point of sale system works today, looking onto a locally held price look-up file on detection of the item code (GTIN) at the point of sale scanner. So it can be with licence plate RFID, and this is the essence of the Savant architecture proposed by EPCglobal and already being developed by solution providers. Savants can be "trained" to push data to locations where it is predicted that the information is or will be required, thus attempting to ensure that the required data is available ahead of the arrival of items associated with that data. Hence there is no need to always "go looking" for data pertinent to a licence plate code when detected. For more on Savant see Appendix 2.

Data alignment and data synchronisation are the existing, standardised processes by which trading partners exchange and maintain the currency of information (respectively) today to facilitate trade, and the traded items are identified using (typically) barcoded "pointers" (the EAN.UCC "Keys").

As for the argument that the Internet is too often slow or not available, the retort is that it is rapidly improving and data storage and processing costs are tumbling down. Some of the envisaged applications are not sharply time critical anyway. The barcode is only a licence plate, so it is specious to argue that it cannot be replaced with one.

3.9.2. Data capture on the tag or not – a summary

At IDTechEx, we believe that there is a place for both licence plate ("number plate") and data-rich tagging. The main arguments for data on the network are that it constrains tag costs, particularly important when large numbers are involved, and reduces the chance of data inconsistencies. In projects involving active RFID, the tag cost is usually a small component of overall cost of ownership of the system, in stark contrast to most large passive tag systems, so compromises to get tag cost down are less compelling with active tag systems.

RFID tags may be remotely written to at intervals or have extra data beyond ID put on the tag at the start. For example, warranty status, service manuals, planned maintenance schedules, security checks etc may be updated for the product that the tag identifies.

More sophisticated tags may carry out data processing. The data and/or processing may or may not be duplicated between the two locations. To summarise, the reasons for moving beyond a dumb number plate include:

- Networks are not always available or working.
- Cost of network programming and access may be prohibitive for certain applications.
- Speed of accessing the network may be inadequate.
- There may be a need for redundancy (certainty of availability).
- Ability to respond to fraud by relocating and improving defences is an important part of the specification of some systems.

3.10. Privacy concerns for data on tag or network

Privacy issues can also dictate whether data is stored on the tag or network. For example, airlines have decided not to put full customer information on the customer's baggage tags, because their competitors might break the security and read this information and use it to their advantage. Adding encryption methods to the tag would significantly increase the cost of it, therefore personal customer information is stored on their network and not on the tag. Conversely, there are applications where the opposite is required.

Privacy will become a bigger problem when these networks are connected to the Internet. TCP/IP is relatively insecure and we all know of the stories of corporate computers and even police and government ones being hacked into and sensitive data copied. Companies may therefore be very cautious in linking their databases to the internet, as envisaged by The Internet of Things and some other forms of Total Asset Visibility (TAV). Privacy is discussed further in Section 6.3.

3.10.1. Continuous monitoring or not

Even where it is practicable to have real time monitoring of stationary items it may be impracticable or too expensive to monitor them continuously when they move.

Real time input usually means long range

Indeed, one ultimate dream of most TAV is to have real time input all the time. This usually implies the more expensive, large tags that work at long range rather than vast numbers of interrogators though proponents of The Internet of Things favour achieving the same thing with heroic numbers of short range interrogators that electronically hand-over to each other. Again, we have a

spectrum of choice, with increased tag and system cost as the degree of sophistication increases. See table 3.4.

Table 3.4 **Spectrum of choice from short to long range**

SHORT RANGE		LONG RANGE	
Monitored occasionally at certain times and places.	Continuously monitored when in range.	Monitored at will.	Continuously monitored.
LOW COST		HIGH COST	

Source: IDTechEx

3.11. Open and closed service provider access

Open systems are where many service providers (including possibly competing ones) are welcome, even solicited to participate, provided they obey the rules. Air baggage tags are one example, barcodes on Consumer Package Goods (CPG) are another.

Closed systems do not usually require standards (ultimately global standards) to be negotiated between competitors. This can be a very lengthy process. One organisation is in charge. Nearly all active RFID schemes to date are closed, though there is a grey area between closed and open systems which can evolve into open ones. Open systems are usually a bigger prize that is further away though de facto standards from a dominant player may speed the adoption process. Where security is paramount, as with a large number of active tag schemes, being closed is a positive advantage.

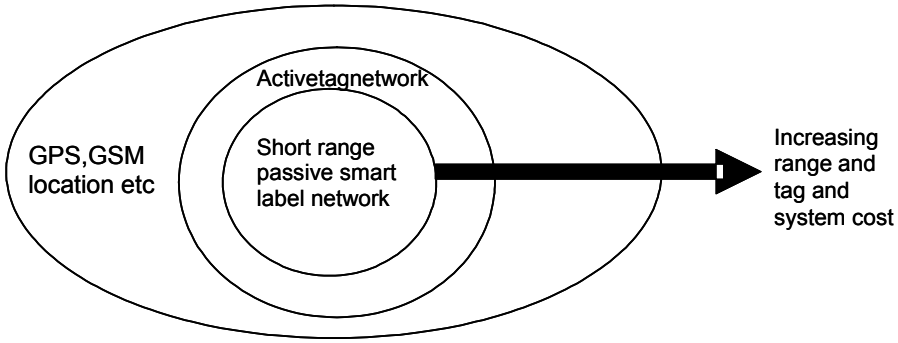
3.12. Networks within networks

Active RFID tag price usually varies from 3 per cent to 30 per cent of total system cost, but for car clickers it may be 45%, so a hierarchy of tags is unavoidable. There must be networks within networks in many applications given that tag-to-tag communication is too expensive for almost anyone apart from the US Military for the foreseeable future. The practical option for most TAV is interrogator-to-interrogator – a "Russian doll" communication.

The hierarchy of "nesting" networks is necessary because tag cost-performance is so wide-ranging but also because the allied infrastructure also varies from low-cost : minimal features to high cost : feature rich. Figure 3.9 illustrates this.

Fig. 3.9 **Networks within networks – the "Russian Doll" approach**

Savi Technology, which coined the term "Russian Doll", has an antenna hierarchy for RFID networks, notably in a supply chain.



Source: IDTechEx

Towels to roll cages to trucks

If the interrogators in the various networks 'talk' to each other, one can create a situation where, say, towels are tracked in relation to roll-cages that sometimes carry them. These are tracked in relation to trucks that carry the roll cages. You know where the towels, roll-cages and trucks are at all times and where they should be. This is done at lowest cost because the towels have very cheap short range smart labels and interrogators and the roll-cages and trucks have progressively more expensive, more functional long-range smart labels, as is justified by the higher value of what they are tracking (i.e. a full roll-cage or truck). The objective is usually to know where everything is at all times or most of the time.

Although no one application will have all the cost-benefit options nested within each other it is important to realise that the tool kit of options breaks down even further at the lowest system cost per tag.

Typical choice of active tag parameters is becoming as in table 3.5.

Table 3.5 **Choice of active RFID tags – typical cost, range, memory in 2003/2004**

TYPE	TAG COST DOLLARS	RANGE METERS	MEMORY K BITS
Read-write chip	0.5 to 1,000	1 to 100	1 to 1,000
Read-only chip	0.5 to 500	3 to 3,000	0.02 to 0.5

Source: IDTechEx

The choice is not therefore cut-and-dried, with higher cost meaning longer range and more memory and read-write capability etc. Indeed, there are many other cost-sensitive parameters such as whether securely-segmented memory or a microprocessor is required in the chip.

Appendix 3 gives the view of Savi Technology concerning achieving efficient global logistics execution. It covers how the convergence of real-time data collection technologies, wireless networks and web-based applications are creating new opportunities for supply chain efficiencies.

The decision whether to address markets that are open or closed to service providers is extremely important in marketing terms for RFID. For instance, supermarket branches already stop customers stealing trolleys and walking out with full trolleys without paying by some idiosyncratic non-standard tag on the trolleys. It does not matter if a sister branch achieves this with someone else's RFID product. That is a closed market, easy for a small company to tackle and gratifyingly rapid in success for the branch. Delivery bins supplying produce to the supermarket chain can end up in any branch so this is a tougher RFID assignment because all branches of the one supermarket must use the same thing by agreeing an internal standard. That is a closed application for the supermarket group as a whole.

Tougher still is RFID tagging every item sold because this is only practicable if done in manufacture as with present barcodes. That is an open system. A piece of manufactured candy say, can go anywhere, to any retail outlet. All must agree standards. The standards must ensure compatibility of operation but also cover such aspects as ensuring that erroneously identical tags will never be produced, despite many organisations doing the encoding and placement. The technology must be cost-effective even for the most unforgiving route to market for the candy.

Open markets are usually very large but there are few of them : the opposite is true of closed markets. Closed markets are often well supplied by small specialists but the large players can usually also participate by adapting their volume products. Indeed some closed markets are quite big : TransCore became one of the world's largest RFID companies largely by serving closed (i.e. single service provider) road tolling applications.

3.13. Ad hoc networks

In the case of the sophisticated active tags used by the US Military, and being developed under European Commission money for postal services, one can easily create ad hoc networks. This emulates what happens in a crowded room when a child is lost. People pass on the message "Where is she?" until she is located then the message filters back that she is found and where she is. Tags that can talk to tags permit a similar thing to happen with certain military freight. Thus many short ranges become one long range. Items can be found or, in reverse, the item can get the message through that it is being overheated or stolen etc.

The same can occur when, for cost reasons, it is the interrogators, rather than the tags that communicate with each other. One could even have ad hoc networks within networks, the common factor being that the structure is created for the task in hand and dissolved when the task is completed. The European Commission ParceForce project has been looking at the feasibility and

usefulness of ad hoc networks in the postal service. Ad hoc networks are usually only practicable with active tags.

3.14. The importance of interoperability

Interoperability between systems not only progresses their merging into TAV, it is massively beneficial in its own right. There are many technical benefits that lead to improved reliability, fault tolerance and so on but the commercial benefits are even more important. They include:

- Promotes creation of multiple supply chains from multiple vendors, reducing procurement risk. Monopoly pricing can be rejected.
- Simplifies procurement by facilitating technology comparison by system operators.
- Separates infrastructure procurement from tag procurement – separates high cost/low volume system procurement from low cost/high volume procurement of connectables such as tags. Simplifies procurement in this way.
- Continuous competition for infrastructure expansion and new tag business – economically most efficient for the operator. Lowest cost or greater benefits delivered.
- Allows geographic expansion from multiple operators (e.g.. of non-stop road tolling systems) to proceed without co-ordination in technology selection.
- Reduces complexity of procurement for large projects. Simpler expansion.
- Encourages new supply chains for connectables and direct sales to users by third party outlets. Increases user choice.

Users may require millions and billions of tags, from different suppliers, all read by different readers supplied by different companies, for the information to flow through different databases and for different inputs to work seamlessly together (e.g.. RFID, biometrics, GPS, video etc). This calls for extensive standards. Major TAV systems will require sets of standards encompassing far more than any other standards seen today.

TCP/IP as a network protocol has been successfully proven in a relatively short time and we will see TAV grow as separate closed systems and services are 'tacked' on to the Internet, followed by larger, open systems.

3.15. Multi-frequency, multi-protocol interrogators

An important aspect of all this is the need for multi-frequency, multi-protocol interrogators for RFID tags. This is because there will never be one ideal frequency for all applications and the protocols – the way the data is transmitted – will not be simplified rapidly by the profusion of incompatible standards and proprietary technologies that are evolving. The very versatility of RFID

creates the need for universal readers and maybe even universal read-writers – the two basic types of interrogator.

Thus Wal-Mart will insist on one type of device to read most types of tag. AWID and ThingMagic of the US and SAMSys of Canada are among those developing such devices, initially for reading several types of tag at one or two frequencies only, with or without modules for versatility of customisation.

3.15.1. Supplier Case study : ThingMagic

For example, the first product of ThingMagic operates in the HF and UHF band and is targeted to cost under $100 in "reasonable" volumes. Prototypes have been tested at AIDC, Wal-Mart and Coca-Cola. The company argues that the RFID Reader of the future will:

- Operate on more than one band.
- Speak multiple air-interface protocols.
- Offer the ability to effortlessly upgrade protocols.
- Speak internet protocols natively.
- Be an integral part of a distributed client-server system.
- Incorporate agent-like behaviour to manage a tag population at a fine grained level.
- Not require human intervention to fix problems.

The RFID reader of the future must have flexible software to match its flexible hardware.

The software design goals are:

- Complete hardware-software modularity:
- Device drivers to abstract the hardware from the software.
- Any protocol module can talk to any band module.
- Modularise the software as much as possible:
- Combine common software elements into modules.
- Provide real-time OS services to all software modules.
- Communicate easily with non-real-time network processor.
- Communicate fluently with the networked world:
- Speak TCP/IP and SQL natively with a built-in database server.
- Interface directly with enterprise systems.

ThingMagic seeks to achieve high flexibility at low cost by:

- Applying software radio techniques to RFID.
- Building modular analog subsystems.
- High level of SW and HW integration across all bands.
- Supporting standard TCP/IP interface via Ethernet to leverage network.

A software radio is a radio whose channel modulation waveforms are defined in software. This decouples the logical functionality – the bits – from the physical radio frequency waves – the photons – thereby offering maximum flexibility.

3.15.2. Supplier Case Study: Savi Technology UDAP

Another aspect of interoperability is any protocol that is tolerant of different data capture devices. Savi Technology has a Universal Data Appliance Protocol (UDAP) protocol which can interface with any data capture device, thus allowing for multiple data capture technologies to be used on a single operating platform.

UDAP is a standardised network protocol that leverages the simplicity and power of XML to provide a common language for data collection devices. The protocol works as follows: as devices are connected to a UDAP network, they describe their features, functionality and characteristics to the rest of the network by way of an XML document. Based on this document, the Savi SmartChain Platform can properly configure each device and map its functionality to the appropriate software applications. During system operation, XML messages are passed between devices and the Savi SmartChain Platform to transfer collected data, initiate specific device functionality, monitor device performance and perform many other system functions.

UDAP provides:

- A standard interface between disparate data collection systems and backend enterprise software.
- "Forward compatibility" for new devices and technologies.
- Plug and play capabilities with RF readers, barcode scanners, and other data collection devices.
- Simplified site installation and configuration.
- Remote network management with optimised network reliability.
- Broad industry adoption.
- Integration with supply chain security solutions such as biometrics, motion sensors and video imaging.

UDAP features:

- XML-based solution that is highly extensive and allows for the transfer of multiple elements in a single message.
- Simple command response protocol enables easy configuration and administration.
- Automatic recognition and registration of new devices on the network greatly simplifies installation and enables a unique level of interoperability with varied data collection devices.
- Flexible an extensive device description document automatically describes all relevant characteristics of devices on the network, including properties, methods and events.
- Each device can have its own unique characteristics, with new characteristics being added at any time.
- Devices can extend their capabilities without changes to the basic UDAP protocol, other devices, or the software layer.

- Automatic monitoring of device availability and status.
- Devices can generate alarm events to indicate device problems.

UDAP partners

UDAP partner encompass the complete spectrum of wireless collection and identification technologies, ranging from providers of barcode, RFID and GPS as well as wireless application development and integration services. In addition partnerships encompass a broad array of supply chain security solutions, including biometrics, motion sensors and video imaging, which can be linked through UDAP to the web-based Savi SmartChain software applications. The list of Savi UDAP partners continues to grow. Some of the current UDAP partners are given below.

Table 3.6 **Savi UDAP partners**

3M	RF Code
Apexion	SAMSys Technologies
Bistar	SCS Corporation
Checkpoint Systems	Sensormatic
Identec	Sphereo Actitrack
iRay	Technology Systems International (TSI)
Lynntech	Tyden Tek
Matrics	VYTEK Wireless
Microlise	WhereNet

Source: Savi Technology

Putting it into practice for the DoD

The following is an example of handling very varied inputs.

In 2003, Savi Technology provided hardware, software, documentation, training, and engineering services for a fully-integrated source of supplies and services at the US Department of Defense. The contract dealt with the supply and use of active transponders with a memory size of 128 Kbytes and an omni-directional read-write distance of 100 meters and a battery life of four years. Also involved are short-range passive chips and real-time locating systems (RTLS) items with the ability to provide continuous, real-time monitoring of assets, read distances up to 100 meters indoors and 300 meters outdoors without any direct line-of-sight, and tag location accuracy within 3 meters.

3.16. Choice of frequency

The commonly used licence free frequencies for active RFID are shown in table 3.7 but 125 MHZ to 132 MHz is increasingly popular.

Table 3.7 **The commonly used licence free frequencies for active RFID**

BAND	132KHZ	13.56MHZ	315 MHZ	418MHZ	433MHZ	868MHZ	915MHZ	2.4GHZ
Detail	119-136 KHz 72dBuA/m @10m	13.553-13.567 MHz 42 dBuA/m @10m	314.7-315 MHz 65 dBuV/m @10m	418.95-418.975 MHz 10mW ERP	433.050-434.790 MHz 10mW ERP 10%	868-868.6 MHz 25mW ERP 1%	902-928 MHz	2400-2483.5 MHz
Range (passive)	Very Short	Very Short	Very Short	Very Short	Very Short	Very Short	Short 1	Very Short
Range (active)	Short	Short	Long 2	Long 2	Long 2	Long	Long	Long
Range adjustment	Very Good 3	Good	Fair	Fair	Fair	Poor	Poor	Poor
Propagation through materials	Excellent 3	Very Good	Good 2	Good 2	Good 2	Fair	Fair	Poor
Directionality	Omni-dir	Omni-dir	Directional or omni-dir	Directional or omni-dir	Directional or omni-dir	Directional or omni-dir	Directional or omni-dir	Directional or omni-dir

Source Savi Technology

Table 3.8 gives the permitted bands by territory

Table 3.8 **The main permitted frequency bands for RFID by territory**

BAND	132KHZ	13.56MHZ	315MHZ	418MHZ	433MHZ	868MHZ	915MHZ	2.4GHZ
Detail	119-136 KHz 72dBuA/m @10m	13.553-13.567 MHz 42 dBuA/m @10m	314.7-315 MHz 65 dBuV/m @10m	418.95-418.975 MHz 10mW ERP	433.050-434.790 MHz 10mW ERP 10%	868-868.6 MHz 25mW ERP 1%	902-928 MHz	2400-2483.5 MHz
Germany	Yes	Yes	No	No	Yes	Yes	No	Yes
France	Yes	Yes	No	No	Yes	Yes	No	Yes
UK	Yes	Yes	No	No	Yes	Yes	No	Yes
Netherlands	Yes	Yes	No	No	Yes	Yes	No	Yes
US	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Singapore	Yes	Yes	Yes	No	Yes	Yes	Yes	No
China	Yes/No	Yes	No	Yes	Yes/No	No	No	No

Source Savi Technology

The most active area in terms of permitted radiation levels has been the recent attempts to make some UHF frequency near to 900MHz legal in all countries for RFID at practicable power levels and therefore ranges. As a result, Japan and Korea have now ceased to ban some such frequencies for RFID and have released certain ones, with China likely to follow suit.

No ideal frequency for everything

Various proponents of active tags have written papers advocating the ideal frequency for active tags and they do not agree. Variously they advocate 433MHz, UHF (i.e. around 900MHz) and higher frequencies such as 2.45GHz and 5.8GHz while others have successful business selling active tag systems based on 125 KHz.. In fact, they are all correct. Let us explain.

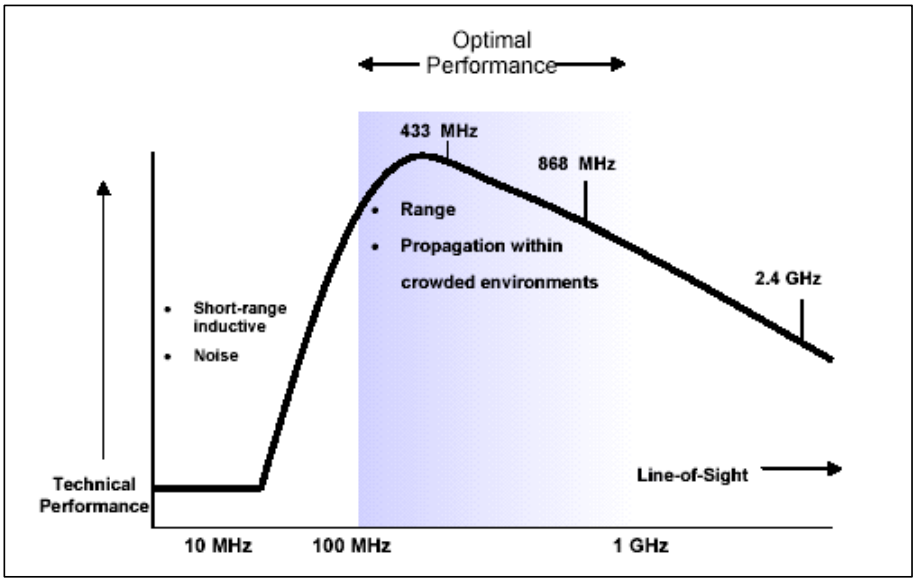
A tag that can be interrogated at only a few metres with a great deal of metal and/ or water in the vicinity usually has to be operated at low frequency such as one in the permitted band from 125 to 135 KHz.

If, like Savi Technology, you are usually tagging big objects such as intermodal freight containers where there are other containers and vehicles in the neighbourhood, or like Texas Instruments you are making car clickers for similarly crowded metal environments where beams cannot penetrate, you want the signal to diffract around things of that size and you usually choose 433MHz.

If, like TransCore, you are doing non stop road tolling or monitoring of railway carriages from gantries and bridges, there is usually nothing more than a vehicle windshield in the way. You are more concerned about high speed of interrogation, because things are moving so fast, so you choose UHF, 2.45GHz or, if pushed, 5.8GHz. The narrowness of the beam at these frequencies may also be of value.

Savi Technology, a proponent of 433 MHz systems, presents its view in figure 3.10, where we have added a note that, at low frequency, one is flooding an area and the tag can be "seen" round corners and through cracks whereas at high frequencies one is aiming a beam which means individual tags can be located in space. Those making car clickers (remote immobilisers) have a similar view to Savi Technology in favouring 433 MHz. However, WhereNet and others perform similar tasks very successfully with 2.45 GHz.

Fig. 3.10 **Technical performance for active RFID in crowded environments as a function of frequency in the view of Savi Technology**



Source Savi Technology

Another aspect is power conservation, which may be less at certain frequencies and, with semi-passive tags, the preference for the most popular passive frequency, which is 13.56 MHz and a good cost-performance compromise in tagging small items. The same interrogator can be used for passive and active tags at that frequency.

3.16.2. Ultra Wide Band

Ultra Wide Band UWB is the use of a broad band of frequencies usually in the higher microwave frequencies to carry out wireless communication. It was only approved for RFID by the FCC in February 2003. Ubisense and Parco Wireless are among the companies taking advantage of this.

Benefits

Proponents of UWB active RFID argue that it offers

- Unprecedentedly high security
- Low power consumption
- Immunity to interference
- Very low probability of causing interference
- Low cost

However, the US Military opposed the use of UWB and the FCC took a long time to approve its use partly because it was more complex than considering whether a single frequency would cause problems with other equipment. A very wide range of frequencies is involved. We do not yet know of a comparison being made in situ between a leading conventional active tag system and a UWB system so the jury is out on that one.

3.16.3. Supplier Case study: Parco Wireless

Parco Wireless has an equipment authorization awarded by the Federal Communications Commission (FCC) in the US for the company's RFID UWB Precision Asset Location system. Figure 3.11 shows the elements of this system.

Fig. 3.11 **The elements of the Parco Wireless UWB RFID system**

Source: Parco Wireless

Parco claims to be the exclusive provider for Ultra Wideband (UWB) technology in healthcare. Parco argues that UWB is safe in hospitals, as it creates no interference with digital or analog devices. It says a key feature of UWB is its immunity to interception, which ensures secure transmission of patient information and supports HIPAA compliance. With its large data carrying capacity and ultra-low power consumption, UWB is ideally suited for healthcare environments in the view of Parco.

Cost Saving

The Parco system uses ultra-wideband pulses to provide "sub-foot precision for the two-dimensional and three-dimensional location of RFID tagged objects". Company CEO, Scott Cohen, sees the FCC's approval of the company's transmitting and tracking devices as a major cost savings victory for the organizations that stand ready to benefit from RFID.

He says: "The FCC's approval of our tags opens the door for hospital savings, potentially reducing the cost of doing business by hundreds of thousands of dollars each year for every facility that takes advantage of these systems".

Capital Asset Reduction

The savings for each institution will be measured by the reduction of capital assets purchased annually and the increased efficiencies in workflow of the operating rooms. Hospitals can realize major increases in efficiency by enjoying a precise accounting of moveable hospital assets and patients.

According to Mr Cohen: "We know of some hospitals that are losing upwards of $75,000 each month directly attributable to lost equipment. For these facilities our systems will provide a return on investment within a matter of months."

The UWB RFID tag is roughly the same size as a wristwatch and can transmit continuously for up to five years on a single button cell battery. It has been designed to be attached or embedded into portable hospital equipment. Once a piece of equipment has been outfitted with this device staff can readily find out it's use status along with its current location to within a foot of it's location, thus saving valuable time in managing the utilization of their equipment. Equipment theft by employees or service providers, or loss from patient transfers leaving the facility can be greatly reduced or in some cases eliminated.

Patient Benefits

"This FCC approval now opens up a whole new chest of management tools and processes that hospital CEOs, finance administrators, and nursing administrators can use to plug holes in the continuum of patient care." said Bertrand Dugal, President of Parco Wireless. "But the biggest winner with this award certification will most likely be the patient. They will be afforded a safer healing environment from better-maintained and cleaner equipment. As well, they will benefit from caregivers with more time to dedicate to their hospital recovery."

Figure 3.12 shows the Parco UWB tags

Fig. 3.12 **Parco UWB RFID tags**

Source: Parco Wireless

Table 3.9 gives the specification of the Parco UWB RFID systems showing that the benefit is taken in a smaller battery rather than increased range.

Table 3.9 **Specification of the Parco UWB RFID systems**

PAL 650 TAG SPECIFICATIONS	
PERFORMANCE	
Typical Indoor Range	300 feet
PHYSICAL AND MECHANICAL	
Standard dimensions	1 7/8 inch diameter ¾ to 1 ¼ inch height
Weight	1.5 ounces
Mounting Options	Adhesive Tag, Screws, Straps
RADIO	
Transmission Power	1 microwatt peak
Transmission Range	5751 – 7001 MHz
PROGRAMMABILITY	
Transmission interval programmable	.01 second to 8 hours
ENVIRONMENTAL SPECIFICATIONS	
Temperature	0º F to 149º F
Humidity	0% to 95%, non-condensing
Housing	Water and Dust Resistant
ELECTRICAL	
Battery	3.0V Lithium (replaceable)
Typical Life	up to 5 years
CERTIFICATION	
Radio	FCC Part 15 class F, QCJPAL650 Ultra-Wideband (UWB)
WARRANTY	
Length	Lifetime (not including battery)
PARCO PART NUMBER	PT-EA-0201-001

Source: Parco Wireless

3.16.4. Supplier Case Study: DSRC Industry Consortium

The US government is funding four companies from mid 2004 to use a development of RFID across a range of frequencies in the region of 5.8 GHz, a frequency already used for some non-stop road tolling RFID systems. The four have started work on this new generation of RFID products aimed at bringing greater safety and new wireless applications to U.S. roads. The U.S. Department of Transportation's Federal Highway Administration (FHWA) has chosen the four companies that already provide the largest RFID toll deployments in the U.S. They will jointly develop dedicated short-range communications (DSRC) technology systems for a trial as part of the agency's efforts to cut road fatalities in the U.S. by 50% within 10 years. The companies are Mark IV industries, Raytheon, SIRIT and TransCore

Safety paramount

The goal is to use DRSC to enhance the safety and the productivity of the US transportation system. The DSRC prototype initiative is a prerequisite for introducing new applications such as issuing alerts to drivers about impending intersection collisions, rollovers, weather-related road hazards, or warning a driver that his vehicle is going too fast to safely negotiate an upcoming curve. DRSC technology could also be used for commercial applications such as downloading driving maps. The non-stop road tolling function will be subsumed in the new systems.

"There is nothing that current systems do that DSRC systems won't be able to do in a breeze—while it's idling in fact," says Richard Schnacke, vice president of industry relations for TransCore and the chairman and spokesperson for the DSRC Industry Consortium. The group's members consists not only of the four companies selected to develop the DRSC-system prototype, but also includes Atheros and Intersil, two major suppliers of 802.11 WiFi chipsets. The 802.11 standard covers this frequency as well as the more popular 2.45 GHz.

Great potential

The promise of DRSC, which its proponents consider a subset of RFID, is to deliver much higher data rate and range to wireless highway applications. "Compared with existing RFID toll applications, DRSC will deliver data rates of 25 Megabits per second, instead of 250 kilobits, and a range of up to 1 km, instead of 10 meters," says Schnacke.

Key to this is the U.S. Federal Communications Commission (FCC) dedication of a large block of radio frequency spectrum, from 5.850 to 5.925 GHz (the 5.9 GHz band), to DSRC applications.

Definitions

RFID and DSRC have been used synonymously to describe a technology based on tags and readers. However, in this use of the 5.9 GHz band, more attention is being given to differentiating these terms. Although the 5.9 GHz DSRC system will essentially consist of tags and readers, it will differ from traditional RFID. The DSRC system will be more like a peer-to-peer system in which either end of a link can initiate a transaction; traditional RFID systems operate in a master-slave arrangement. This peer-to-peer architecture will be necessary because many planned applications are vehicle-to-vehicle ones, not involving the roadside RFID readers at all.

Other differences

DSRC and traditional RFID differ in other ways: DSRC will use a modulation type that breaks data down into small parts and transmits them in parallel within a wide channel, whereas traditional RFID sends everything in series over a narrow channel. This basic difference makes it possible for DSRC to offer a much higher data Transmission speed than RFID can achieve. Because of its long read-range, DSRC must be able to operate in a condition of multiple overlapping communication zones something that most RFID systems today cannot achieve. DSRC must also dynamically control such things as emitted power, channels and message priorities—things that current RFID systems cannot do.

DSRC consortium

The DSRC Industry Consortium, formed in late 1999, held its first meeting in February 2000. It has received $1.3 million from the FHWA in the first phase of the DRSC prototype initiative. Designs for the first DRSC hardware were completed in four months. These systems will consist of roadside monitors and sensors that can detect certain road conditions and situations and then transmit related information to DRSC transceivers installed in vehicles. Funding for the manufacture and testing of the systems, which is expected to take an additional 11 months, has not been disclosed.

Any DRSC system would require DRSC technology to be built into new vehicles. The in-vehicle components would likely consist of a DRSC transreceiver linked to warning signals or lights to alert the driver of any impending danger. A number of major automotive manufacturers are already studying the potential for such systems, say TransCore.

4. Active tag construction

4.1. Overall construction

An active RFID tag, whether used in semi-passive, semi-active or fully active mode, consists of a microchip, typically requiring 5000 or more transistors, an antenna and a battery. Other devices may also be included such as external capacitors and sensors.

4.2. Batteries

4.2.1. Battery overview

So far, most active RFID tags have employed conventional batteries both rechargeable and disposable. Technologies include cadmium, lithium and silver based electrolytics and the size of them has varied from coin size to AA batteries and palm sized batteries . For the future, however, there is great interest in making disposable, low cost laminar battery constructions and there are many development programmes in universities, research centres and elsewhere to this end. We now discuss the batteries beginning to be used in the new, smaller active RFID tags.

Many types of battery are being developed for active RFID and similar applications but none are fully biodegradeable. The basic choices emerging are compared in table 5.1. Primary, i.e. disposable, and secondary, i.e. rechargeable, versions are available but, as yet, there is little call for rechargeable versions despite the fact that Infinite Power Solutions say theirs can be recharged by the signal beam in active RFID applications. The lithium batteries are usually rechargeable but tend to be employed for single use in labels and packaging. Table 4.1 compares the small batteries that are the way of the future.

Table 4.1 **Shapes of battery for small RFID tags advantages and disadvantages**

SHAPE	PRO	CON
Coin/ button	Well proven, mature technology, relatively powerful. Small footprint.	Usually lithium based – special disposal demanded. Relatively expensive. NiCd versions becoming illegal. Silver versions are expensive. All are relatively thick – usually at least 1 mm.
Paper thin	Power Paper version well proven and environmentally excellent. Others have power and power delivery rate as plusses. Thin – a few microns to 0.3 mm. Very flexible but more powerful versions less so.	Power Paper version has modest capacity and shelf life. Large footprint. The more powerful ones are less environmentally friendly being usually lithium based and more costly. All versions use plastic.

Source: IDTechEx

As a consequence, most attention is on paper thin versions in packaging because here the footprint (area covered) is rarely a constraint and the thinness and low cost are valued.

4.2.2. Coin type batteries

Coin type batteries are otherwise known as button batteries. They are available in silver and lithium versions. An example of a tag using such a battery was shown in figure 3.12. Suppliers include those in table 4.2 and technology choices are compared in table 4.3.

Table 4.2 **Examples of suppliers of coin type batteries by country**

SUPPLIER	COUNTRY
Hitachi Maxell	Japan
Seiko Instruments	Japan
Matsushita	Japan
ShenZhen Gaonengda Micro Battery Co Ltd	China

Source: IDTechEx.

Table 4.3 **The spectrum of choice of technologies for batteries in smart packaging**

TECHNOLOGY	PRO	CON
Manganese dioxide/zinc e.g. Power Paper	Low cost	Low power Low current 1.5 years shelf life.
Mainstream lithium i.e. most suppliers	Higher power and current Long shelf life.	Environmentally sensitive Thicker Costlier
Advanced lithium	High temperature. Very rapid power delivery.	Costliest

Source: IDTechEx

We now look at some of the laminar batteries that are available or planned.

4.2.3. Power Paper

The Power Paper battery is shown in figure 4.2. It is activated by pulling a tab.

Fig. 4.1 **The Power Paper battery**

Source: Power Paper

The Power Paper batteries represent a breakthrough in micro-power source technology, the primary features being:

- Ink-based printable energy cells.
- Thin and flexible.
- Disposable and environmentally friendly.
- Any shape.
- Any size.

They are already used in electronic time temperature indicators on packages and have great potential in merchandising, display and other functions in packaging. In addition, Power Paper envisage ultra low cost active RFID tags with long range, based on their batteries as in figure 5.5 and timers for hair dye etc have been developed as shown in figure 5.6. The RFID labels may cost as little as 50 cents in volume vs several dollars for conventional active RFID tags that are more bulky but have longer life on the shelf and in use.

4.2.4. Solicore, USA

Air Products and Chemicals, Inc., and Solicore, Inc., a manufacturer if innovative solid polymer lithium ion batteries and advanced battery manufacturing systems, have entered into a joint development agreement and an equity investment, made by Air Products in Solicore, to enable the development of advanced lithium polymer battery technology and commercialisation. This completes Solicore's series B preferred financing round of $15 million, including Air Products' strategic investment.

Ultra-thin and flexible

Solicore creates ultra-thin flexible batteries that have greater power density and are safer, lighter and more compact than today's products, according to the company. To achieve this goal, Solicore

has developed patented, next-generation solid-state electrolyte technology and unique manufacturing processes. Unlike conventional lithium ion batteries, which contain a liquid or gel-based electrolyte, Solicore has pioneered an electrolyte that is a non-compressible, non-combustible, and non-toxic plastic film. Cells can be created in any shape or formed into a variety of designs. Thus, while these batteries do not have the environmental credentials of Power Paper batteries or the low price, they are more powerful and will be seen in some smart packaging.

4.2.5. SCI, USA

SCI Engineered Materials, the operating entity of Superconductive Components of the US and its project partners received a $1.2 million award from the Third Frontier Action Fund it late 2003. This fund is administered by the Ohio Department of Development with the objective of expanding the state's high-tech research capabilities and create new jobs.

Lithium thin-film batteries

The award is to scale-up manufacturing processes to produce materials to be used in lithium thin-film batteries. SCI Engineered Material's portion of the award is approximately half. SCI says it will use the $600,000 to purchase manufacturing equipment for the process.

SCI has now moved into a larger manufacturing facility. It increases capacity to manufacture two critical materials, lithium orthophosphate and lithium cobalt oxide. SCI Engineered Materials hopes to deliver in larger quantities low-cost, high-quality sputtering targets to its customers, which produce Lithium thin-film batteries.

Very thin

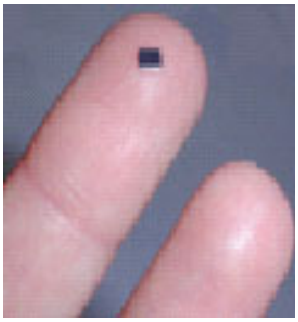
Lithium thin-film batteries are 15 to 25 microns thick (one-fourth the thickness of a human hair). They provide flexible power for a wide range of applications, including RFID tags, smart cards, portable electronic devices, such as cellphones and portable computers, and, in the future, medical devices.

Superconductive Components manufactures advanced ceramics such as superconductors, ferroelectric and optical materials for use in wire, cable, batteries, wireless and fibre optics systems. The company also provides materials for thin-film applications used in more than 40 countries in photovoltaics, electronic switches, hardness and decorative coatings.

4.2.6. Infinite Power Solutions, USA

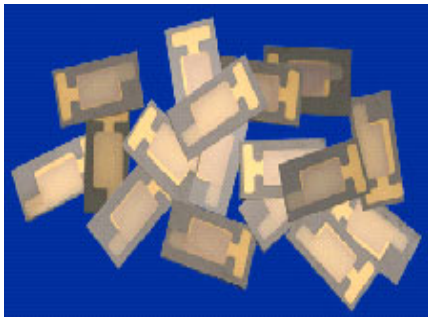
Figures 4.3 and 4.4 show the batteries of Infinite Power Solutions, a company profiled in a case study later.

Fig. 4.2 **The Infinite Power battery is very small**



Source: Infinite Power Solutions

Fig. 4.3 **Infinite Power batteries ready for use**



Source: Infinite Power Solutions

A rechargeable 12 micron-thick lithium battery is available today from Infinite Power Solutions of the US that enables products to operate where they could not before.

Initial research on rechargeable thin-film solid-state lithium batteries dates back to the 1990s at Oak Ridge National Laboratories, USA. Today's micro-power product solutions are available for applications that can benefit from the small size, long-life and extreme high temperature performance capability afforded by these power supplies. Such battery cells are ideally suited to support a wide range of product applications including consumer electronics, medical implants, RFID tags and labels, smart cards, remote sensors and military applications.

Characteristics of the battery

Production cells today are deposited on various substrates such as aluminium oxide ceramic and metal foils. The battery is claimed to be environmentally friendly, and with its thin form and long life can be configured for nearly any low-power battery application and designed to fit nearly any product battery envelope requirement.

The most robust production µA-Hr battery cells manufactured today by Infinite Power Solutions implement a crystalline lithium cobalt oxide cathode that per square centimetre of active cathode area provides capacities of approximately 200 micro-Ampere-Hours with the capability to support

steady current power requirements of 5 milliAmps and pulse (approximately 100 msec) current power requirements of greater than 40 milliamps with a voltage greater than 3.0 Vdc. This robust battery can also survive a wide storage temperature range (-50ºC to + 150ºC) and has also shown capability to deliver reliable power at temperatures as low as -40ºC and as high as 160ºC with continued charge/discharge cycle capability.

A different way of thinking about batteries

From a performance standpoint, the Lite*Star battery from Infinite Power Solutions has the capability to replace nearly every other battery for every product with increased capacity according to the company.

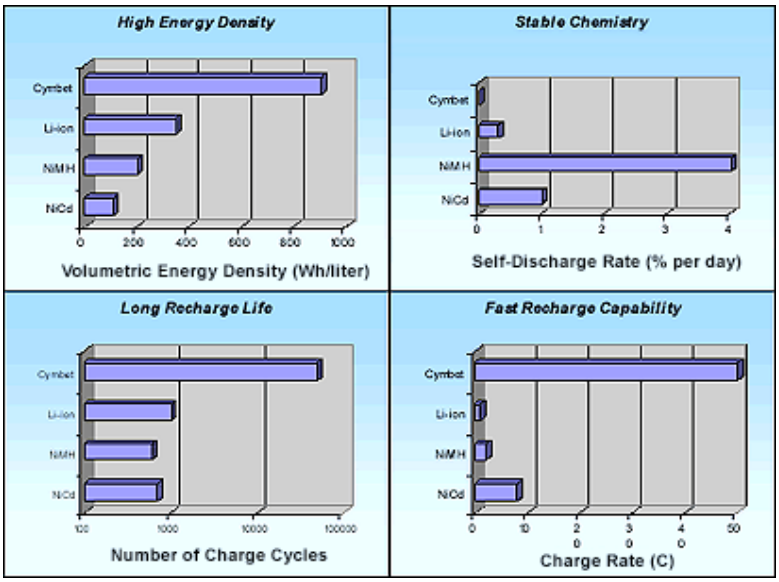
4.2.7. Cymbet, USA

Cymbet of the USA also has a very thin, flexible lithium battery which can be the size of a postage stamp as in figure 4.5. Cymbet claim the superior properties in figure 4.6 for their thin film batteries. However, they are not necessarily the most powerful on the market for given applications.

Fig. 4.4 **Cymbet lithium thin film flexible battery**

Source: Cymbet

Fig. 4.5 **Relative performance claimed by Cymbet for its flexible batteries**



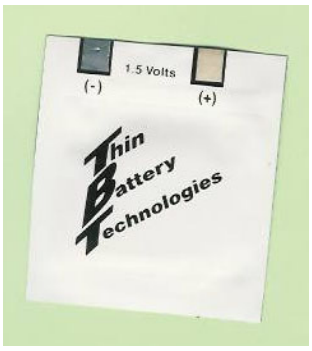
Source: Cymbet

Table 5.3 gives some sources of thin film batteries applicable to packaging. Many are pre commercial at present.

4.2.8. Thin Battery Technologies

A new manganese oxide zinc disposable battery has been announced from Thin Battery Technologies. It is made under license from Ever Ready with collaboration from Precisia for high volume deliveries and it is shown on figure 4.7 . Better environmental protection and temperature performance are claimed vs earlier versions on the market. Thickness is about 1 millimeter max and the battery is highly flexible. It can be made in almost any format and it is environmentally benign.

Fig. 4.6 **Manganese dioxide-zinc thin film battery from Thin Battery Technologies.**



Source: IDTechEx

Table 4.4 **Examples of potential sources of flexible thin film batteries**

COMPANY	COUNTRY	TECHNOLOGY
Power Paper	Israel	Manganese dioxide Zinc primary
Stone Battery	Taiwan	"Any existing electrochemistry" used to make laminar, flexible batteries by "rivet" technology. Primary or secondary.
Infinite Power Solutions	USA	Lithium primary/ secondary
Voltaflex	USA	Lithium primary/ secondary
Cymbet	USA	Lithium
Excellatron	USA	Lithium
Angeion	USA	Lithium
ITN Energy Systems	USA	Lithium
Solicore	USA	Lithium polymer
KIST	Korea	Lithium
Toshiba	Japan	Lithium
NTK Technical Ceramics	Japan	Lithium
Ridge Microenergy	USA	Lithium
Thin battery Company	USA	Manganese dioxide Zinc

Source: IDTechEx

4.2.9. Research

Research in thin film batteries is carried out at a rapidly increasing number of universities and research centres, including those in table 4.5.

Table 4.5 **Examples of universities and research centres developing laminar batteries.**

Cornell University US	Ultra small battery
Sandia National Laboratories US	Rechargeable thin film all ceramic battery
National Cheng Kung University China	0.1mm thick flexible lithium ion battery
Germany	Five Fraunhofer members of the Microelectronics Alliance
Iowa Thin Film US	Thin film batteries
Naval Research Laboratory Washington DC US	Developing rechargeable batteries on microchips
Oak Ridge National Laboratory US	Fundamental research

Source: IDTechEx

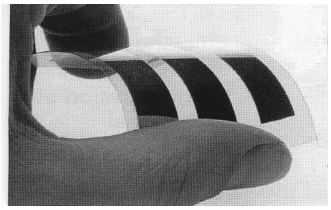
4.3. Fuel cells

Ultra small fuel cells are being developed to perform the function of an extra powerful microbattery. They may also offer unusually rapid power delivery where required but they are unlikely to be the cheapest option. In packaging, fuel cells are likely to be disposable i.e. acting like a primary battery not like conventional fuel cells. Such disposable fuel cells are already sold for recharging cellphones. Aluminium-Power Inc of the US is involved.

4.4. Photovoltaics

At first sight solar cells, i.e. photovoltaics, are a poor bet for active RFID because most applications have the tag spend a great deal of time in the dark or near darkness. However, the power from photovoltaics can be stored for hours by capacitors and for days by batteries. Therefore a cheaper, smaller battery may suffice even where range is enhanced over passive RFID i.e. in semi-active and fully active RFID. That is why we have solar powered torches. The inefficiency of cheap flexible photovoltaic structures such as those employing organic semiconductors can, to a degree, be compensated for by the large area available on many packages. An example of a flexible photovoltaic film is given in figure 4.8.

Fig. 4.7 **Konarka photovoltaic flexible film**



Source: Konarka

In fact, there is steady progress in improving the very low efficiency of today's flexible polymer photovoltaics. Researchers at Siemens AG report increasing the efficiency of printed organic solar cells from 3% to over 5%. Solar cells, that are made from organic semiconducting polymers, are manufactured in a printing process. The photoactive layer of the cell has a thickness of approximately 100nm. As the polymers are printed onto foil they result in a lightweight and flexible solar module.

This figure of over 5% is claimed to be the highest obtained for printed organic solar cells to date. The researchers believe that at these levels of efficiency the technology has the potential to be commercially viable. It is thought possible that efficiencies of 7% can be achieved with the current state-of-the-art technology.

Christoph Brabec, development leader, says: "Our efforts are partly concentrated on replacing non-organic technology." He adds: "We mainly aim at new markets that we can open up because of the great benefits of our solar cells."

Other power sources for active RFID

Other power sources for packaging may arrive, such as storing the energy from vibration, movement (see end of section 3.4.4) or heat. However, for the foreseeable future, they do not seem likely to serve more than niche applications in packaging.

4.5. Active RFID with sensing

Active RFID is increasingly used with some sensing capability. It is not that passive RFID cannot do sensing. This is a hot area of university research because it would be a more reliable, cheaper solution than active RFID though the data can only accessed when an interrogator is in range and operating. Active RFID offers a full range of capability in sensing from humidity to temperature/ time and many other functions and laminar, disposable Smart Active Label (SAL) versions are now available such as shown in figure 4.9.

Only a processor can fully organise, collate and store sensor data at present, or handle multiple sensor inputs. For example, Savi Technology has some tags in military applications that operate in this way and KSW Microtec has Smart Active Labels that sense these parameters at a fraction of the price of conventional active RFID, albeit with more primitive polling and other capability. Table 4.6 compares the capabilities.

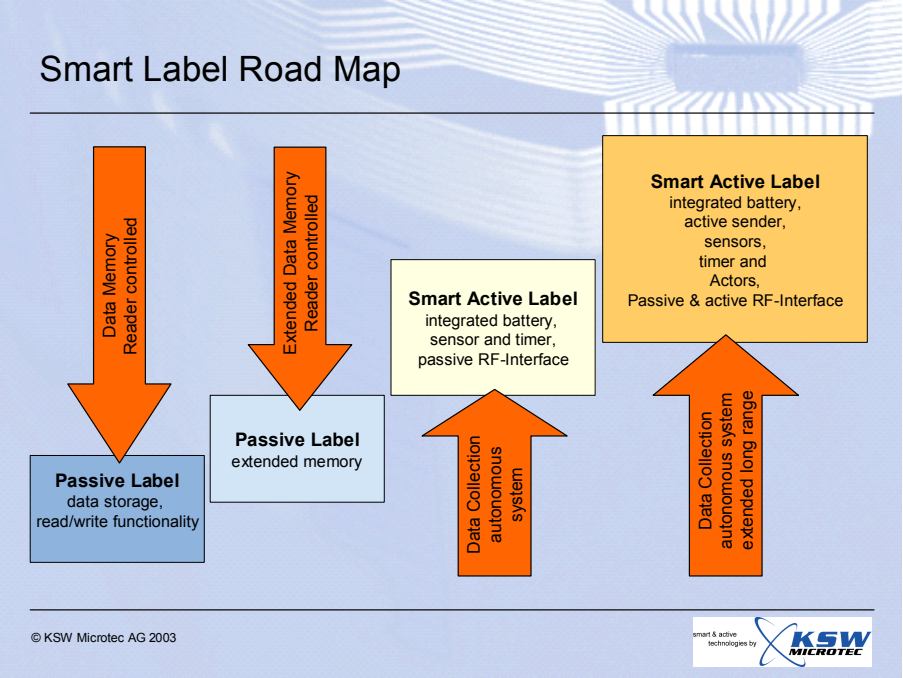
Table 4.6 **Comparison of conventional active RFID with temperature/ time recording and Smart Active Label (SAL) versions.**

PARAMETER	CONVENTIONAL	SAL
Size	At least many cubic centimeters	Credit card size
Mode	Semi-active	Semi-passive
Range	30 meters	One meter
Battery life	7-10 years	3 years
Number of recorded events	Tens of thousands	70-300

Source: IDTechEx

KSW Microtec sees the evolution in figure 4.10.

Fig. 4.8 **Smart label road map**



Source KSW Microtec

The KSW Microtec semi passive SAL is shown in figure 4.9. Unfortunately, although the battery does not boost range, the company still chooses to refer to this product as semi-active.

Fig. 4.9 **Semi-passive RFID label from KSW Microtec**

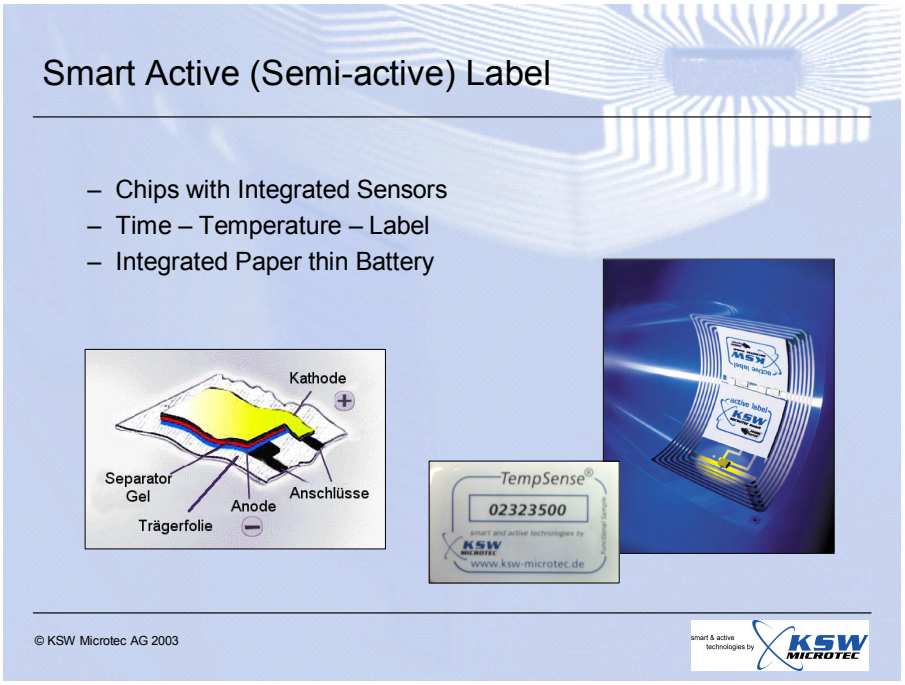
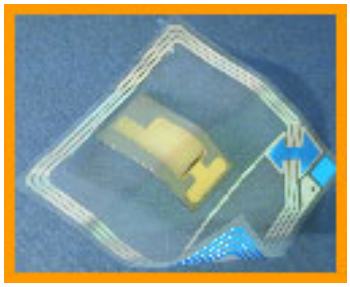


Fig. 4.10 **Infinite Power Solution flexible lithium battery as part of a semi-passive tag.**



Source: Infinite Power Solutions

5. Standards, privacy and allied technology

5.1. Standards

5.1.1. Standards for active RFID systems

There are various applicational standards for active RFID and it is increasingly involved in other standards as cost of ownership of such systems makes them more widely applicable. For example, as an acknowledgement of the growing importance of 433 MHz as a carrier frequency for active RFID, a proposal has been submitted for a simultaneous new work and item committee draft on the parameter for air interface communications as "part 7" of the ISO 18000 series for RFID item management. ISO 18000 is the only data transfer standard in the overarching ISO series of global standards on RFID. ISO 18000 is subsuming the proposed Electronic Product Code EPC standards for tagging very large numbers of items with unique identity. Active tags will have a significant part to play in this "tag everything" scenario called The Internet of Things and companies such as Savi Technology are already installing EPC active tag systems. It envisages the communication between RFID and other systems Thing to Thing (T2T) as being primarily over the internet to save cost and it is discussed fully in Appendix 2.

If the recent work developing and marketing Smart Active Label forms of active RFID tag results in commercial success, then the larger volume applications may become cost effective and this will call for new standards or subsets of standards. Partly this is chicken and egg – without standards, large open applications for SALs will not be feasible. In acknowledgement of this, the SAL-C consortium is working on its own proposed standards but this effort is at a very early stage. We now look at RFID standards in general to put this in context.

5.1.2. Benefits of standardisation

A number of benefits are generally attributed to effective standards, including:

- Enhancement of user and supplier confidence through the published specifications and supporting information that form the standard.
- Enhanced awareness and acceptance of standards' objectives.
- Usually, the availability of multiple sources of the same or similar products that meet the basic requirements of the standard.
- Simplification in respect of systems, services, systems efficiencies and maintenance.
- Supportive elements in improving processes and procedures.
- Applications growth and developments facilitated by the compatibility or interoperability that standardisation may offer.
- Platform for the development of other standards, products and / or services.
- Market growth, encouragement of competition and reduction of component and system costs.

Where standards are agreed at international level the benefits are generally seen to support objectives relating to global trade, communications and technology transfer. RFID is of such significance that international standardisation has been identified as an imperative. Because of the activity at a national and interest group level on RFID standards requirements, it is useful to gain some insight into the contributory elements at these levels to the international process and the developments that have relevance to standards at industry level.

The exploitation of technology in the form of products and services, offering scope for widespread, national and international usage for domestic, business or commercial benefit, invariably requires the support of standards. They facilitate compatibility and interoperability within the applications arena. Even in situations where an innovative product from a single supplier gains rapid and widespread market impact the need generally arises for a standard or standards to support the 'diffusion process' both in terms of application growth and expansion of the supplier base for supporting technology. In such circumstances the proprietary specification may be seen as the vehicle for a de facto standard. Proposals for standards may also evolve in other ways, be developed and accepted through a formalised standardisation process, as industry or national standards. Where standards are required for global usage progression from national standards may impose problems due to lack of harmonisation leading to what is often described as technical barriers to trade.

Such observations hint at the importance of standards. However, to gain a more incisive view of their role and their significance with respect to RFID and smart labels in particular it is necessary to distinguish what is meant by standards and the various forms they can take.

5.1.3. Types of standard

A useful starting point is to consider the definition provided by the International Standards Organisation (ISO):

"Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for purpose."

In the context of RFID including smart labels the reference to technical specifications or other precise criteria may be considered to embrace four types of standard:

Technology Standards - dealing with the technological features, such as the air interface communications format and data exchange protocols, that have to be agreed to assure compatibility or interoperability in systems produced by different manufacturers or systems providers.

Application Standards – dealing with agreements on the way or ways in which technology or systems are to be used in particular applications to ensure consistent usage in a specified manner. Many devices only require technology standards. However, open systems application standards using data carriers have to ensure that data created at a source has to be perfectly understandable by any, even unknown, recipients. Application standards often set parameters and associated values, which constrain the associated technology standard in terms of performance or other features. The application standard may incorporate the data standard, or refer to an external data standard.

Data Standards - dealing with the agreements on the way data is structured for compatibility and interoperability requirements.

Conformance Standards – dealing with agreements that specify the way in which systems are to perform to be acceptable with respect to particular performance or operational criteria.

Because of the 'radio' or electromagnetic nature of RFID the conformance requirements extend to particular regulatory demands with respect to electromagnetic spectrum usage. RFID data carriers (tags or transponders) and associated systems may be viewed as short range devices (SRDs), sharing spectrum with other short range entities such as telemetry systems and radio alarms. As with any class of spectrum users they are required to comply with requirements concerning licensed or unlicensed operational parameters, electromagnetic compatibility, interference immunity and safety. These regulatory aspects are in addition to the basic technology standards and can differ between countries and regulatory authorities, and may be changed over time. Regulations relating to short range devices can generally be distinguished for particular bands and power levels and are invariably specified at national level according to nationally defined needs. As

a consequence national regulatory specifications can often be seen as a source of non-harmonisation when viewing needs for international standards.

5.1.4. Open and closed application systems

In the absence of standards the take-up of technology is essentially confined to closed system usage, generally characterised by agreement between, and under the control of system planners as to what is used and how it is used. Such systems are often specified within particular organisations for use by those organisations in a way that is effectively under their control. For example, a company may agree a pallet-tagging scheme that uses a particular type of RFID tag and associated reader / data transfer system. Where the company has a number of divisions or associated companies and there is movement of pallets between them an agreement may be made to use the same pallet tagging / reader system in each organisation concerned. The agreements are internal or between the respective organisations and as such they are effectively closed by the system specification and associated agreements. A client company or companies handling the pallets may wish to exploit the tag facility by acquiring appropriate reader systems. In such circumstances the system specification has to be acquired from the originating organisation or another system user. Large or even very large closed systems can emerge in this way. This is a useful and significant feature of technological development in which the exploitation of technology by enterprising organisations provides visibility of applications potential and the prospects for wider use.

If the usage evolves to an industry level the system specification may be accepted as a de facto standard, thus opening up the system usage on a wider scale. However, within this evolutionary phase other organisations within the same industry may adopt different systems for achieving the same functions on an internal or restricted basis, similar to the initial intervention. Competitive opportunities, technological developments and product diversity each contribute to the diversity of systems subsequently adopted on closed system basis. Where system commonality is recognised as a basis for improved inter-organisational functions and efficiencies, a collective body may see the need to agree the form that the system commonality should take. In other words agree a standard that would allow universal or open system usage. The need for commonality may be expressed in terms of data, technology, conformance or application requirements. The relevance of RFID, including smart labels, to virtually every sector of industry, commerce and services where items and data are handled points to the need for appropriate standards. Such standards will better support closed system applications and facilitate open systems usage through the availability of published specifications and supporting information. Where standards are harmonised or structured as international standards the open systems opportunities relating to global trade and data exchange can be significantly increased.

Stemming from the commonality features are the attributes that distinguish the importance of a standard, not least of which is the impact they can engender with respect to technology take-up. Before considering the standardisation issues for RFID it is useful to reaffirm the importance of standards by considering the benefits that standardisation has to offer.

5.1.5. Standards organisations

Various organisations may be distinguished that have an active role in developing standards and may be conveniently grouped into Industry, National, Regional and International Organisations. At the international level the organisations having particular relevance to information and communications technology are International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC), the United Nations International Telecommunications Union (ITU).

At the regional level standards developing organisations include, Comité Europeen Normalisation (CEN), Comité Européen Normalisation Electrotechnique (CENELEC), Comité Européen Postal and Telegraph (CEPT), European Telecommunications Institute (ETSI) and the European Computer Manufacturers Association (ECMA). At national level the list increases considerably, including bodies such as the British Standards Institute (BSI), American National Standards Institute (ANSI), Japanese Information Standards Association (JISC) and other national bodies around the world.

At the Industry level the list is extensive, including trade associations and professional bodies representing particular sectors of industrial activity making use of the data carrier, including for example, the Uniform Code Council (UCC), EAN International , Automotive Industry Action Group (AIAG),the International Air Transport Association (IATA), and the United Postal Union (UPU). In addition, the vendor community is represented by, for example: the Automatic Identification Manufacturers Association (AIM), and the Institute of Electrical and Electronics Engineers (IEEE).

At this level applications standards can be frequently encountered, often based upon international technical standards. The AIAG transport label standard is an example, based upon international bar code symbology specifications. The IEEE 802.11 standard, strictly speaking a technology standard, for Wireless Local Area Networks (WLANs) is a further example of a standard being developed through a professional body and having cross-industry, worldwide, significance.

Also identifiable within the standards development arena are interest groups of various kinds, usually structured to pursue a particular area of standards development. It is within this framework of stakeholder interests and complexity that standards are formulated. Where proposals for standards have cross-boundary requirements the need for national co-operation becomes imperative. The international standards organisations consequently involve national and regional partners.

5.1.6. Types of standard relating to item level RFID

There are about 140 ISO standards for RFID. However, there is only one item levels series of standards now being progressed and the backers of EPCglobal and its predecessors have now abandoned attempts to create another separate one. Most of the RFID standards are applicational ones for such things as road tolling, bank cards, travel tickets and animals.

Richard Rees, president of Scanology, a European RFID systems provider and chairman of the British Standards Institution committee for RFID and barcodes puts it this way :

EPC and ISO; they do different things and are not in conflict. EPC is a complete system to carry, capture, store and access supply-chain data whereas ISO-18000 is just a data carrier.

EPC numbers can be carried in many data carriers: they can be put into a bar code, printed on paper and scanned, or even tapped into a PDA. They can be carried by any RFID tag with sufficient memory, including an ISO 18000-compliant RFID tag.

The ISO standards are written so that one protocol can cover all kinds of tags, including tags that carry a simple license plate (ID), store very complex data, and are read-only, WORM (Write Once Read Many) or read-write.

ISO standards are a reality today. The ISO UHF standard 18000-6 is near enough to final approval that companies can create products based on it. 18000-6 tags are available right now. My company and others are supplying them to the end users.

He feels that the current EPC data carriers have done good work for proof of concepts in the United States. They have also been tested in Europe and Asia under special short-term licences but he counsels that there are no EPC products available that can operate under European regulations.

For open systems applications, ISO 18000-6 is currently the only UHF data carrier that meets global regulations, can carry both existing data structures and the proposed EPC data, is available from a variety of vendors and can be purchased today.

EPC protocols

Recently, I was privileged to convene a meeting of experts from all sides of the RFID community in Edinburgh, Scotland. Their conclusions:

The Auto-ID Center's Hardware Action Group (HAG) is developing next-generation protocols that will be compliant with global regulations, but that program can't deliver commercial product until at least 2006.

The extra functionality being developed by the HAG would be of most value to item-level identification, which is predicted to start in 2007 or later.

There is no technical reason why the HAG work could not be backward compatible with 18000-6.

So the road map is clear:

If you need to put in a UHF RFID system right now—the applications will generally be at pallet or case level—then it makes sense to implement ISO 18000-6 in either A or B form (your integrator should be able to advise which is most appropriate).

When item-level tagging starts in, say, 2007, you can continue using ISO 18000-6, and/or you can introduce second-generation EPC technologies. Either way, you do not need to disturb your investment in readers, especially if you have installed multi-protocol readers, such as those from SAMSys.

This solution makes it possible to deliver what Wal-Mart and its suppliers need now and will need in the future. And it solves the problem of having two competing RFID systems confusing the market.

EPC standards for case/pallet level are undecided as yet but the intention is to merge the existing, evolving ISO 18000 series with the needs of EPC by expanding EPC beyond being simply a concept of read only tagging at any frequency as required. At item level, other requirements need to be settled beyond the frequency, protocol and so on. Some potential suppliers and users envisage a sell-by-date being encoded, the Stock Keeping Unit (SKU) and so on, not just a unique number. This is because the original concept of EPCglobal of keeping everything on central databases interrogated over the internet is not seen as always practicable. ISO standards are therefore being written to include a wider range of options including read write and active (with battery) tags.

Figure 6.1 shows how the writing of standards is following the progression of feasibility and cost effectiveness of the different applications. First came vehicles, then bulk containers, then we shall have item level on the grand scale but these applications and standards come last. Figure 6.1 is only an indication of some of the vast complexity of work going on that is relevant to item level tagging.

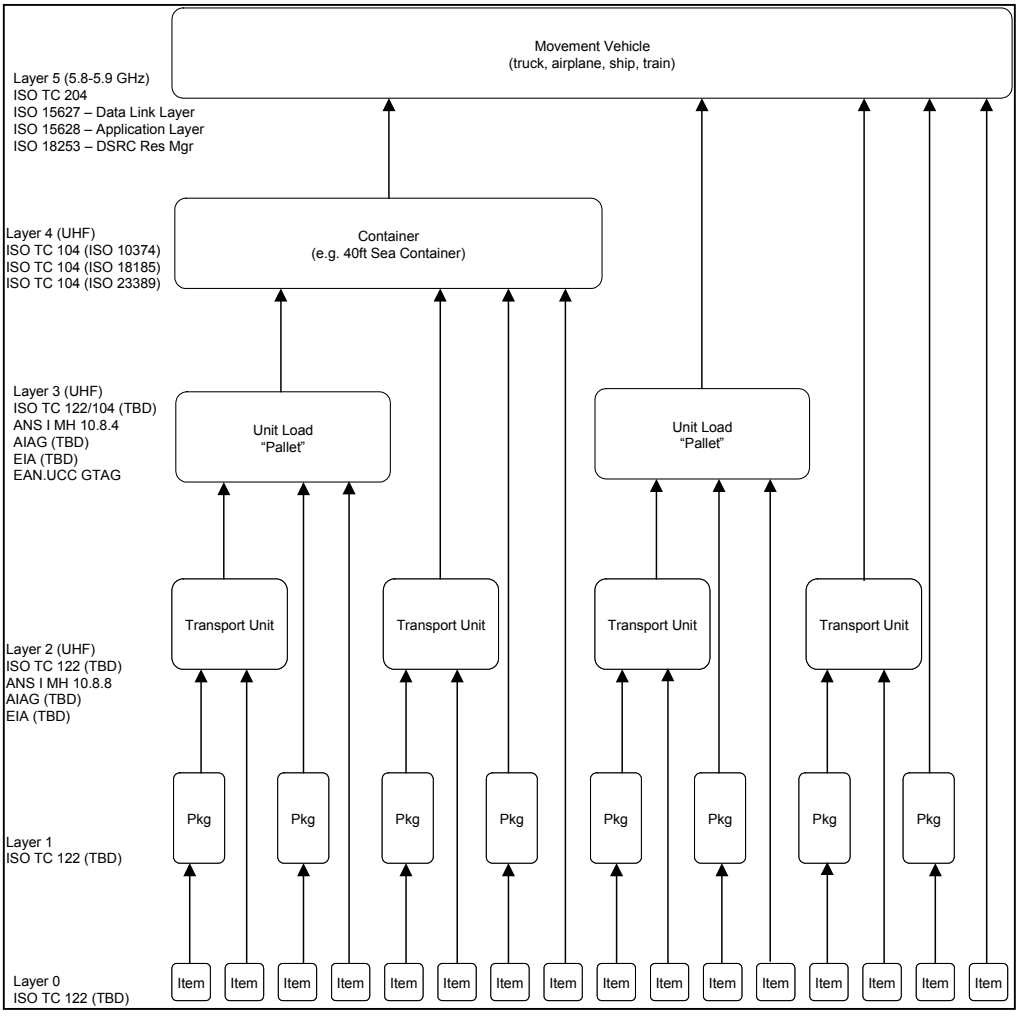
Fluid situation

Indeed the situation is so fluid that we entered 2004 with proposed item level standards at 5.8GHz being abandoned as it was realised that this frequency is only used to any great extent for road vehicles with line of sight or near line of sight reading and need for very fast reads. It is not useful for virtually any mass items. 433MHz standards had reached final committee draft, ready for final ballot. However, 433MHz is virtually only useful for battery driven tags where range is typically 30 meters or more and its advantage of diffracting around bulk containers, vehicles etc can be enjoyed. That is very much a niche for item level tagging if only because of the size, cost (typically $10-30 today but with a prospect of 20-50 cents primitive versions in a year or two following initiatives of the Smart Active Labels Consortium and its members) and limited life of such tags. It is therefore a sideshow in the world of mass item level tagging. More importantly, 13.56MHz (ISO 18000-3) and 125-134KHz standards have reached the stage of final draft agreed, technical standard finalised and only minor issues to be resolved.

Layers of logistical units

Figure 5.1 shows the layers of logistical units addressed by supply chain standards.

Fig. 5.1 **Layers of logistic units. Those more likely to employ active RFID are at the top and those least likely are at the bottom. The earliest adopters of any form of RFID are at the top and therefore it is these that first had standards.**



Source: Derived from ISO TC122 discussion document

5.2. Radiation regulations

In most major countries there are regulations concerning the maximum electromagnetic power that can be emitted at various frequencies. There have been large differences across the world and the significance for RFID is that tags working at a given frequency may have a permitted power and therefore range varying by a factor of one hundred. Indeed, in Japan and Korea, UHF has been banned for RFID. The situation is summarised in table 5.1

Table 5.1 **The permitted frequency bands for RFID by territory**

BAND	132KHZ	13.56MHZ	315 MHZ	418MHZ	433MHZ	868MHZ	915MHZ	2.4GHZ
Detail	119-136 KHz 72dBuA/m @10m	13.553-13.567 MHz 42 dBuA/m @10m	314.7-315 MHz 65 dBuV/m @10m	418.95-418.975 MHz 10mW ERP	433.050-434.790 MHz 10mW ERP 10%	868-868.6 MHz 25mW ERP 1%	902-928 MHz	2400-2483.5 MHz
Germany	Yes	Yes	No	No	Yes	Yes	No	Yes
France	Yes	Yes	No	No	Yes	Yes	No	Yes
Great Britain	Yes	Yes	No	No	Yes	Yes	No	Yes
Netherlands	Yes	Yes	No	No	Yes	Yes	No	Yes
US	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Singapore	Yes1	Yes	Yes	No	Yes2	Yes	Yes	No
China	Yes/No	Yes	No	Yes	Yes/No	No	No	No

Source: Savi Technology

Considerable progress in harmonising UHF RFID Figure 3.12 gives the permitted bands by territory

The good news is that pressure to have UHF, which gives the longest RFID range under North American regulations, permitted for usable ranges in elsewhere in the world has resulted in Europe easing radiation laws to the point where it is a practicable proposition in Europe i.e. at least one meter vs the previous permitted power level which translated into range of one centimeter or so rendering it a virtually useless licence free frequency.

Japan and Korea join the party

Further good news is that, having previously banned outright the use of RFID at UHF, Japan and Korea are now coming into line in 2004/5, both somewhere in the frequency range of 950-956MHz or so. It follows decisions by both governments to promote the use of RFID and the RFID industry. For example, a new Korean government body will develop country specific regulations in Korea and act as representative in the international development of RFID standards. Mr Han of C&C Solutions in Korea tells us that ranges of over ten meters will be possible. China is also coming into line.

Sadly the frequencies and permitted UHF power remain different

The bad news is that power levels particularly between Europe and the rest of the world will be very different for the foreseeable future, to the disadvantage of Europe, and the precise frequencies permitted across the world remain different, calling for a different silicon chip in each case. This limits economies of scale.

Poor progress at other frequencies needed for item level tagging

Other bad news is that, at 13.56MHz and 2.45GHz, both frequencies likely to be needed for many item level applications, the power levels remain very disparate across the world and work to harmonise these has been less energetic as all eyes have been on opening up pallet and case tagging with UHF worldwide.

5.3. Privacy issues

Figure 5.3 shows a vital task performed by tagging of humans.

Fig. 5.2 **X-Mark Systems "Hugs and Kisses" active RFID on mother and baby prevent mismatching in hospitals. Breast feeding of the wrong child just once can pass on HIV/AIDS.**

Source: X-Mark

Recently, a small number of privacy advocates have been very voluble about what they perceive as the threat to personal privacy from RFID. Many of them spread extreme forms of misinformation on the matter and even those with a more measured view usually advocate strong government regulation and the banning of certain practices such as the tagging of humans. So far, their target has been primarily passive tagging applications, notably tagging everything in shops, because these are the large or potentially largest applications. In fact, the scope for malign invasion of privacy with passive tags is negligible because of their short range and inscrutable and minimal data content. Indeed, those sold in highest volume are read only and contain only an identification number that is incomprehensible to third parties.

Active tags should be more of a concern because they are usually longer range and often read write, containing considerable data beyond simple identification numbers. Nonetheless, it is highly unlikely that any third party could make sense of this information and there is no recording of sensitive personal details. Compared with say video cameras or eavesdropping on cellphone messages, the "threat" from even active tags is very small indeed. In years past, those developing barcodes, smart cards, cellphones and video cameras did not debase their products to meet extreme objections from privacy objectors and the public hugely valued the benefits of such products and massive markets were created.

If there is anything to worry about with RFID it is that EPCglobal has been making, or considering making concessions to privacy advocates that debase their products and greatly limit the potential benefits to society. For example, it has proposed banning use of its Electronic Product Code EPC system for tags used on humans, yet such tags perform such invaluable tasks as automating school evacuation in case of fire, preventing the wrong blood being given to people in hospitals and

locating children abducted by paedophiles in theme parks. EPCglobal has proposed making all tags killable at the shop checkout yet 30% of the paybacks in retailing come after the checkout including improved product recalls to save life.

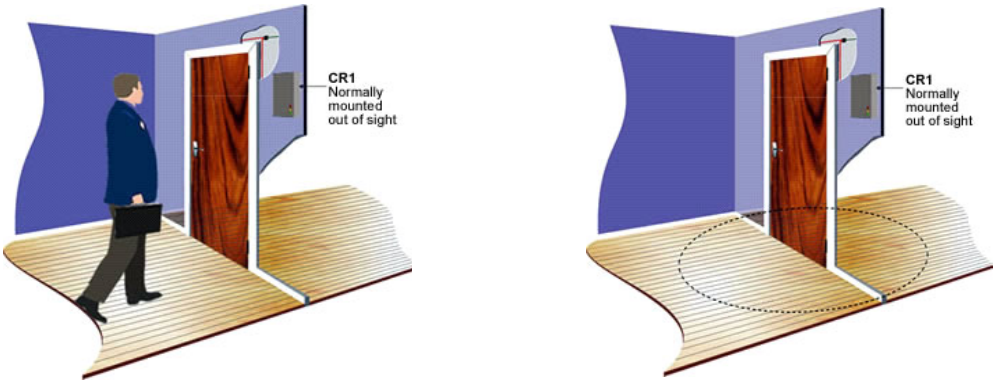
We recommend that proponents of active RFID should do more to promote the benefits to society at large and take great care to avoid putting any easily accessible sensitive data on the tags. National legislation concerning data privacy should be taken seriously of course but the bottom line is that alleged privacy issues should not be the major concern of the industry – timely rollout of systems that prevent errors, save life, reduce costs and otherwise benefit society is far more important. Figure 5.4 shows an active tag used on adults

Fig. 5.3 **Identec semi-active RFID personnel tag. It has three meters range and is dormant when out of range. Safety is a major benefit.**

Source Identec

Figure 5.5 shows an Identec secure access configuration. Such products protect against criminal attack and are a valued achievement of the RFID industry rather than a threat. Figure 565 shows an RFID-based wander prevention system for the disoriented elderly and other confused patients. This gives a degree of freedom to those who may otherwise have to be locked in one room if staff are busy. Again, inflated privacy concerns should not be allowed to imperil life by restricting such uses.

Fig. 5.4 **Identec secure access configuration**

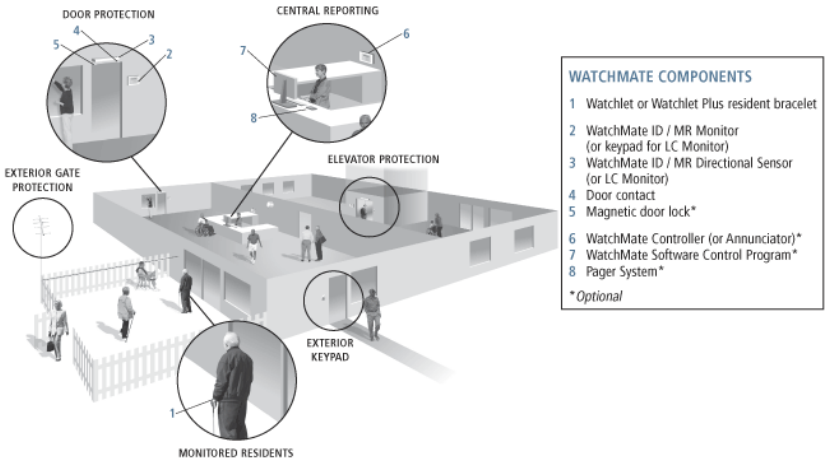


CR1 Installation

CR1 Detection Field

Source: Identec

Fig. 5.5 **X-Mark Systems wander prevention system for disoriented elderly in care homes and hospitals**



Source: X-Mark Systems

Recent report takes a measured view

In mid 2004, the Competitive Enterprise Institute published a report that argued that, despite invasion of privacy fears, legislative controls of RFID would not be appropriate at present. It said, "Prompt deployment of, and experimentation with, RFID would best serve the interests of the public and the economy." It came at a time when some of the first attempts at legislative controls in certain US states were thrown out.

5.4. Bluetooth, WiFi, ZigBee, Active RFID and NFC compared and combined

There are many short range wireless communications devices available now and others are coming along. Typically they do not work at more than 100 meters range. Those that are arousing the most interest are Bluetooth, WiFi, RFID and now ZigBee. Bluetooth and WiFi take a considerable amount of power, so their use is usually constrained to where there are powerful batteries, such as in mobile telephones and laptops, and where there is ac mains power. However, they can bring in and transmit unlimited streams of data, with WiFi winning on speed. Very much at the other extreme, we have had passive RFID, that being where there is no battery in the tag. Because this is the most popular and best known form of RFID, there has been a tendency not to relate this to Bluetooth and WiFi because it is so primitive by comparison. It only "speaks when it is spoken to" meaning it cannot initiate a signal. Indeed, when a passive RFID tag is interrogated by the interrogator sending a signal which it returns with data, those data are often the most primitive imaginable – just a simple ID number. That is a long way from the capability to send unlimited streams of data in both directions. However, at least RFID is self-standing data and the tag can be extremely small, robust and low cost. Bluetooth and WiFi circuits are really interfaces to data.

5.4.1. Bridging the gap

An interesting new development is the bridging of the gap in the market places between the interfaces Bluetooth and WiFi and the primitive data carrier passive RFID. For some time we have had active RFID where there is a battery in the tag. Usually this is used to increase range or make it work in noisy environments, manage data such as encrypting, storing sensor inputs and so on. However, an important use of active RFID is in initiating a signal, say at timed intervals or in response to circumstances. Data reflector becomes data emitter. Indeed, with active RFID much more data can be practically stored and accessed on the tag. It is still not unlimited data streams in both directions, but it somewhat bridges the gap in the market place. In this respect, so-called semi-active RFID where the battery is not on all the time is most useful because the battery can be relatively small and cheap – or, if you wish, extremely long lasting such as ten years.

Secondly, we have ZigBee coming along to bridge the gap in the marketplace between Bluetooth/ WiFi and semi active RFID. It is ZigBee and it is now yet widely available. In most applications, it is expected that ZigBee devices will share the merits of semi-passive RFID in being low enough in power demand to manage on a small cheap battery provided they are configured to be off most of the time. However, ZigBee is intended to be more of an interface than active RFID. Active RFID rarely does more than manage sensors that gather information, this being transmitted to the interrogator with the identification number when required. ZigBee is intended to telephone you when your house is on fire or being burgled and let you switch things on from the other side of the world if necessary.

We summarise the emerging options in table 5.2.

Table 5.2 **Bluetooth, WiFi, ZigBee and Semi-Active RFID compared**

	Bluetooth	WiFi	ZigBee	Semi-active RFID
Power consumption	High  Low			
Typical chosen task	Cable replacement – computer to printer etc	Broadband wireless internet connection	Not yet deployed but: People controlling every appliance in their home	Monitoring location and status of people and cargo, real time tamper alert, remote locking of car.
	At its heart is a communication interface			Based on an identification tag
Duty cycle	Usually on all the time		Rarely on or on for only very short time intervals	
Maximum battery life in these applications	1-7 days	0.5 to 5 days	Over 3 years	3-7 years
Memory required in these applications KB	250	1000	20 to 250	0.1 to 5
Bandwidth kilobits/sec	720	11,000	20 to 250	1 to 1000
Range meters	10	100	70	30-700
Capable of forming ad hoc networks such as tags talking to tags to achieve longer range demanded by a specific task	Not usually		Possible if the system is designed to do this. With active RFID, the tag can even read the more ubiquitous passive tags if so configured.	
Backers	Over 100 companies	Over 100 companies	70 companies including Motorola, Honeywell, Samsung, Mitsubishi Electric and NEC	About 200 companies

Source IDTechEx

5.4.2. Bluetooth and WiFi

When Bluetooth was launched four years ago it was hyped as something that would open many new markets, eliminate all computer, television and hifi cabling and compete with most of the existing solutions for connecting electronics anywhere. However, although it is used for wireless internet services in places like airports, it has to compete with the faster WiFi. Some airports have reported interference between the two systems so Bluetooth may become the loser in these applications. In

monitoring appliances in the home the high power consumption of Bluetooth is seen as a problem with devices powered by small batteries such as smoke detectors. In the office and with cellular phones, Bluetooth can be useful in replacing all those wires but WiFi is a competitor. It is clear that Bluetooth has a place and there are now many Bluetooth devices on the market but it is not clear that Bluetooth will be the biggest business.

5.4.3. ZigBee

ZigBee is rapidly evolving prior to global rollout. One capability that has been announced is the switching on of all ZigBee devices at the same time. Many new power saving tricks are promised. Control of many appliances using cellphones or PDAs is promised. We shall have high speed and optional encryption.

Chris Ryan, an analyst with Future Horizons of the UK forecasts that the average home will have 65 ZigBee devices controlling that number of appliances, toys, robots and so on. However, before looking at what we can do that replaces nothing, Richard Traherne of Cambridge Consultants has pointed to the simple fact that "One of ZigBee's driving forces is reducing the cost of cabling." In other words it will do what Bluetooth was supposed to do and do it better and cheaper.

Whether the technology works or not, the wireless control of the home has some questions attached. Do you really want to control the washing machine from a distance when you cannot load it remotely? Do you want to switch on a kettle at a distance if it is either empty or contains stale water? Do you want to close the garage door remotely when your cat may be hit or trapped? Will it really be possible to control everything in the house from a handheld device without the complexity when, due to pathetic human interfaces, most of us have forgotten how to program the video recorder? One suspects that ZigBee has a place but it may not the "control everything" one that is currently envisaged.

5.4.4. Active RFID

Active RFID, usually in semi-active mode i.e. not on all the time - has taken a place in preventing errors such as mother baby mismatches and erroneous blood transfusions in hospitals, in controlling prisoners and those on parole in near real time and so on. Its place in sensing humidity, temperature, movement etc of ammunition boxes and other military and logistic assets is well established as well as the real time reporting of tampering with intermodal containers under the Smart and Secure Tradelanes Initiative across the world. Active RFID in car clickers will expand to other vehicles.

However, there is an uncertainty and that is what the new, low cost Smart Active Label versions of semi-active RFID tags can be used for. We suspect that the monitoring of logistical assets at 30 meters or so may be big for them, permitting many cases on a pallet to be monitored at the same time and "instant audit" of a warehouse full of goods. Some say the new cards that open the car

when you walk near it will be made that way, though others want to control when they open their car. But all is uncertain at present and partly dependent on the capacity of the new disposable batteries being launched by ten or so companies. If the life in use and shelf life of batteries for Smart Active labels does not economically achieve 3 years or more, then the opportunities dwindle.

5.4.5. Combinations

Given the complementarity of the different options, it is no surprise that combinations are appearing. Bluetag of Denmark has a pendant for people in theme parks that combines Bluetooth and RFID to locate them. Computer interfaces that cope with both Bluetooth and WiFi are appearing.

5.4.6. Near Field Communications NFC

Overarching the functionality of all four of the above options, we now have near Field Communications NFC. However, it would be wrong to portray it as the "glue" that sticks them together in all situations. It deliberately has a range that is far less than any of the above options. The argument for NFC is this. You would not expend a lot of energy and cause annoyance by shouting across a room at someone – you would walk across or ask someone nearby to pass on the message. NFC uses the same principle to link electronic devices. It enables the user to exchange all kinds of information, in security, simply by bringing two devices close together. Its short-range interaction over a few centimeters simplifies identification because there is less confusion when devices can only contact immediate neighbours.

5.4.7. RFID and communications interfaces

Evolving from a combination of RFID and interconnection technologies, it is claimed that NFC technology bridges today's connectivity gap. It enables the simple transfer of information, from phone numbers to electronic transactions. It allows people to interact with each other and with things navigating complicated menus or performing complex set-up procedures.

NFC is promoted as opening up many new opportunities for consumers. It is claimed that it will enable people to effortlessly control and connect digital cameras, PDAs, set-top boxes, computers, mobile phones and so on. With NFC it should be possible to connect any two devices to each other to exchange information or access content and services – easily and securely. As such it builds on and advances basic Bluetooth, WiFi, and RFID technology.

Nokia and others say that, by flashing your mobile phone or PDA near a poster you will download information about the event from a smart chip in the poster. After finding out more about the concert, you can immediately buy tickets and store them electronically on your handheld device. On the night of the concert you can access the venue without ever having the need for a paper ticket.

More than just a wireless connection, NFC is a basic tool allowing a person to instinctively interact with his electronic environment.

5.4.8. A virtual connector

NFC is intended to be used for quickly establishing different forms of wireless communication between devices - a virtual connector. Once the two devices are in close vicinity, NFC should invisibly configure and initialize other wireless protocols such as Bluetooth and 802.11 (e.g. Wi-Fi), permitting devices to communicate at longer ranges or transfer data at higher rates. In an environment rich with wireless-enabled devices, NFC is the easy way to set up connections without needing to go through complicated menus. In a sense it creates ad hoc networks.

5.4.9. Link to RFID smart cards

It is claimed that NFC also offers a unique link to contactless i.e. RFID smart cards. It is compatible with the broadly established infrastructure based on smart card technology, heavily used in transport across the world. This is because NFC devices can operate in an active or passive mode, enabling communication with a wide variety of passive devices, such as contactless smart cards and other passive RFID. This feature also permits mobile devices to communicate in passive mode, saving power and extending battery life.

5.4.10. NFC Forum created by Sony and Philips

NFC technology has been jointly developed by Philips and Sony as a means of overcoming the complexity and incompatibility of modern technology in our increasingly wirelessly connected world. An open platform is sought offering the best benefits for consumers and the industry. To this end, Philips and Sony have allied with Nokia to establish the NFC Forum, which promotes implementation and standardization of NFC technology. NFC will enable users to access content and services in an easy and intuitive way by simply touching smart objects and connecting devices just by holding them next to each other. Other companies are welcome to join the Forum.

5.4.11. Standardization of NFC

Intended to become a widely adapted RF infrastructure, NFC is already standardized by globally accepted bodies, including ISO (18092), ECMA (340) and ETSI. It operates at 13.56 MHz over a distance of a few centimeters. Data rates are 106 kbits/s and 212 kbits/s. NFC is compatible with ISO 14443 A (Philips MIFARE) and Sony's FeliCa smart card protocols, respectively. However, higher transmission speeds can be achieved between dedicated NFC devices -- initially up to 424 kbits/s – with potential for even higher bit rates.

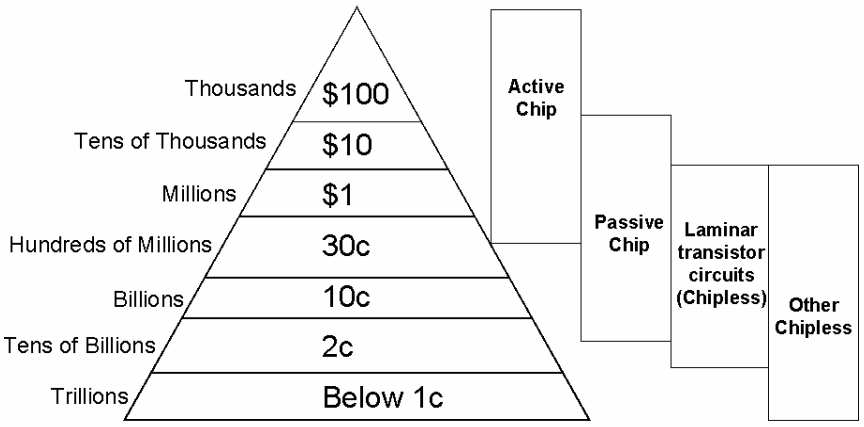
6. Markets

6.1. Price sensitivity

The global market for RFID systems and services will grow as tag price reduces as shown in figure 6.1 but only if systems cost reduces pro rata. Price sensitivity with active tags is not as great as with passive tags because with active tag systems, the tag cost is only 3-30% of cost for most schemes. However, with highest volume applications such as car clickers it is more like 45%, comparable to the highest volume passive tag systems and the advent of SALs may create more active tag markets like this.

Figure 6.1 shows the future lower active tag price leading to larger yearly numbers and the new tag technologies that will make it possible

Fig. 6.1 **The future lower tag price – larger yearly numbers and the new tag technologies that will make it possible**



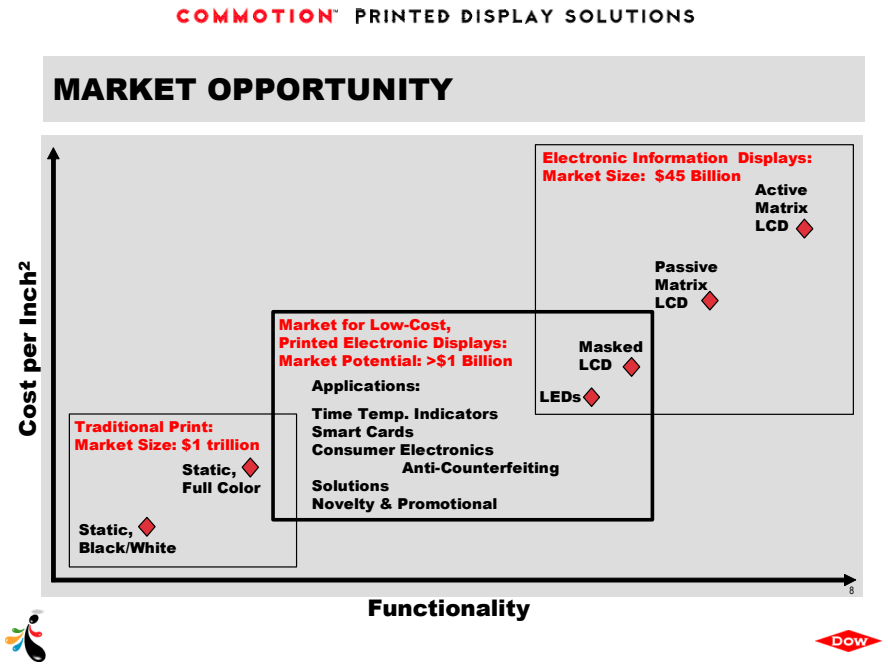
Source: IDTechEx

The laminar transistor circuits will not be available in volume until at least 2005. There are three types – silicon film or polymer film transistor circuits, both on polymer film substrates, and printed circuits on paper. They will have the same circuit designs used in silicon chips today and the same antenna designs but will be cheaper, thinner, more robust and with faster turnaround. Some will be transparent and most will eventually incorporate displays, loudspeakers etc. in the same layer deposition processes, so they will be far more versatile than silicon chip. Currently, there are no other chipless technologies that can be configured as active RFID tags.

6.2. Many bridges to cross

However, for the above price-quantity breaks to happen, many other aspects must fall into place as well. One example of the evolution that needs to be monitored is the availability of low cost electronic displays that are needed on RFID Smart Active Labels so they can be used as disposable self-adjusting use by dates for example. Figure 6.2 gives a projection and sizing of the market for these new designs with functionality between traditional print and the type of display on a television set.

Fig. 6.2 **Market opportunity for disposable electronic displays, including those on RFID Smart Active Labels, as projected by Dow Chemical subsidiary Commotion Printed Display Solutions.**



Source: Commotion

6.3. Forecasts for tags

6.3.1. New markets – hand-held homing devices

Just as the biggest existing application of RFID – car clickers (immobilisers) - does not involve anything being replaced, so may it be with the next major breakthrough. A possible candidate for this may be the location of people and assets using single beams rather than triangulation because of the lower cost and simpler infrastructure. That would open up consumer markets for hand held interrogators to find lost children, track pets and so on that carry a small, cheap active RFID tag as well as ubiquitous interrogators in healthcare, industry etc to home in on specific items, even for the police to chase thieves by homing in on stolen goods.

6.3.2. Remote access fobs for other vehicles.

The largest number of active RFID tags sold today is car clickers. These devices will appear on many other types of vehicle, helping to grow this market. but although this number will grow steadily as other vehicles are given remote locking capability, the largest number and value of active RFID tags sold in 2014 may be RFID Smart Active Labels SALs.

6.3.3. New markets – Smart Active Labels

It is too early to be sure of the nature, let alone the timing of new applications for Smart Active Labels and new variants of them. Candidates include monitoring supply chains at distances unattainable with passive RFID and the self adjusting use by and sell by date that consist of an active RFID smart label with a display that indicates a different sell by or use by date as it detects heating, humidity etc. Eventually this may display the word "Expired" yet the whole device will have to be cheap enough to be disposable. Infratab and KSW Microtec have just launched versions costing several dollars but price will have to come down to 20 cents or so for billion plus yearly sales in our opinion.

6.4. Forecasts for tags 2004-2014

Our forecast for the global RFID active tag market (including semi-active and semi-passive), most of which will be in automotive/ transportation/ logistics/ healthcare/ military, is shown in table 6.1.

Table 6.1 **Forecasts for the number, unit price and value of the global market for vehicle clickers (remote locking), Smart Active Label SAL RFID and other types of active RFID tag from 2004-2014 in millions of units and millions of dollars.**

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vehicle clickers number	45	47	50	52	54	55	56	57	58	59	60
Price	2	2	2	1.9	1.8	1.7	1.6	1.5	1.5	1.5	1.5
Value	90	94	100	99	97	94	90	86	87	89	90
SAL number	5	10	20	50	100	150	250	350	400	900	1500
Price	2	2	1.8	1.5	1.4	1.3	1.2	1.0	0.9	0.3	0.2
Value	10	20	36	75	140	195	300	350	360	270	300
Other tags number	2.5	3.0	5.0	6.0	7.0	8.0	9.0	10	13	16	20
Price	20	19	18	16	14	13	12	11	10	10	10
Value	50	5.7	90	96	98	104	108	110	130	160	200
Grand total number	52.5	60.0	75.0	108	161	213	315	417	471	960	1580
Grand total value	150	119.7	226	270	335	293	498	546	577	519	590

Source: IDTechEx

The statistics for non-stop road tolling/ parking tags, which form a major part of the Other category above are given in table 6.2.

Table 6.2 **Statistics for road tolling/ parking RFID tags worldwide in 2004**

Population	20
Yearly unit sales	2
Percentage that are active RFID	10
Number of active RFID yearly	0.2

Source: IDTechEx

6.5. Forecasts for systems 2004-2014

The spend on active RFID systems – infrastructure, software and systems integration - dwarfs that on tags and will continue to do so. It varies greatly between applications and is forecast in table 6.3.

Table 6.3 **Forecast for the value of global sales of RFID systems excluding tags, for vehicle clickers, SALs and other applications 2004-2014 in millions of dollars**

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vehicle clickers	95	96	97	99	101	106	114	119	120	124	130
SAL	10	15	20	25	30	40	53	65	75	85	100
Other*	150	160	170	180	190	200	240	300	400	550	620
Total	255	271	287	289	321	346	407	484	595	759	850

* mainly military, prisons, logistics and healthcare

Source: IDTechEx

6.6. Forecast for total systems plus tags 2004 – 2014

6.6.1. Dominant cost change

The total spend on active RFID systems plus tags is given in table 6.3. Thanks to SALs , the dominant cost goes from being systems in 2004 to tags in 2014. However, for conventional tags (the Other category), the system cost remains higher than the tag cost component even in 2014.

Table 6.4 **The total global spend on active RFID systems plus tags, in billions of dollars**

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tags	150	120	226	270	335	293	498	546	577	519	590
Systems	255	271	287	289	321	346	407	484	595	759	850
Total	405	391	513	559	656	639	905	1030	1172	1278	1440

Source: IDTechEx

6.6.2. RFID in the prison and parole service

An example of the many substantial niche markets that contribute to the above global market is the potential market for active RFID in the prison and parole service worldwide as discussed at the end of chapter 1. This is estimated in table 6.5 .

Table 6.5 **Global potential annually for active RFID systems plus tags in the prison and parole service**

APPLICATION	GLOBAL MARKET POTENTIAL $MILLION YEARLY FOR SYSTEMS AND TAGS
Tracking prison keys and preventing unauthorized removal	10
Tracking staff	50
Tracking and controlling prisoners	900
Monitoring prisoners on parole	50
Total	1,010

Source IDTechEx

These market estimates are necessarily subjective for two primary reasons. One is that the adoption rate is very uncertain and the other is that alternatives to RFID such as the Wherify tags from the US using GPS may gain penetration. The greatest uncertainty is adoption rate at present because, although GPS can now be made to work in some buildings and urban canyons, the large amount of metal in prisons and the need for absolute reliability and read integrity make them unsuitable environments for GPS and questionable for many near range two way communication technologies such a WiFi, Bluetooth and ZigBee.

Appendix 1

Jargon Buster

Appendix 1: Jargon Buster

A

ADC	Automatic Data Capture
AIAG	Automotive Industry Action Group. Organisation that has created various numbering standards such as tire and identification standard (optical and RFID)
AIDC	Automatic Identification and Data Capture
AIM	Automatic Identification Equipment Manufacturers' Association
AIT	Automatic Identification Technology
ASIC	Application Specific Integrated Circuit
ASN	Advance Ship Notice (automotive)
AVI	Automatic Vehicle Identification – usually RFID.
Acoustomagnetic EAS or RFID	Acoustomagnetic EAS and RFID systems, otherwise known as electroacoustic or, incorrectly, electromechanical, use a transmitter to create a surveillance area where tags and labels are detected. The transmitter sends a radio frequency signal at a frequency such as 58 KHz (thousands of cycles per second). The frequency is sent in pulses. The transmitted signal energizes a tag in the surveillance zone. When the transmitted signal pulse ceases, the tag responds, emitting a single frequency signal like a tuning fork. The tag signal is at about the same frequency as the transmitter signal. The active part of the tag actually vibrates. Its packaging must therefore leave it free to move. It cannot be curved around a surface. When the transmitter is off between pulses, the tag signal is detected by a receiver. A microcomputer analyses the tag signal detected by the receiver to verify that it is at the correct frequency and occurs in time synchronized to the transmitter, at the proper level, and the correct repetition rate. If the criteria are met, an alarm occurs, such as a bell or a signal to a pager on a security official plus zooming in of video cameras. Acoustomagnetic tags can be used on or in most forms of bulk packaging but not primary or paper packaging in the main because they are thick and will not operate if bent. However, the world leader in EAS, Sensormatic (now owned by Tyco) has standardised on them, making them something of a de facto standard in North America and quite popular elsewhere. Heavy, reusable versions are used on apparel for example. See The Smart Label Revolution www.idtechex.com

Active tag	A tag, such as an RFID tag, with its own power source, usually a battery. Some have replaceable batteries and some, called unitised active tags, do not. For more see The Smart Label Revolution and Total Asset Visibility. New active tag inventions and applications are regularly analysed in Smart Labels Analyst www.idtechex.com.
Addressability	The ability to address bits, fields, files or other portions of the data storage in a tag or other data store.
Aerobic micro-organisms	Organisms depending on free oxygen or air. See the new report Smart Packaging www.idtechex.com
Aldehyde	A colourless, mobile, and very volatile liquid obtained from alcohol by certain processes of oxidation. Low molecular weight aldehydes, e.g., formaldehyde and acetaldehyde, have sharp, unpleasant odours.
Algorithm	A step-by-step procedure for solving a problem; in encryption, the mathematical procedure used to create a cipher.
Alignment	In RFID it means the orientation of the tag to the interrogator.
Antenna	Conductive electronic components that radiate and or receive electromagnetic energy in the radio frequency spectrum or thereabouts. An aerial on an RFID tag or interrogator, for example..
ANSI	American National Standards Institution
ANSI X12	American National Standards Institute EDI Standard.
ASCII	American standard code for information interchange. ASCII is a seven bit code with an eighth bit used to describe the format for transmission and for storage.
Audit Trail	A chronological record of computer activity automatically maintained to trace all use of the computer. For security it is preferable that the record be maintained by the operating system.
Authentication	The process of establishing the validity of a message or of verifying a user's authorisation for access to data.

B

B2B	Business to Business
B2C	Business to Consumer
B2D	Business to Distributor
B2E	Business to Employee
B2G	Business to Government
BAPT	Battery Assisted Passive Tag. US Military tag using battery to manage sensor data not increase range
BI	Business Intelligence such as data mining
BPI	Business Process Improvement
BPM	Business Performance Management
BPO	Business Process Optimisation i.e. process engineering.
Barkhausen effect	An effect employed in one form of chipless RFID tags where an interrogatory electromagnetic field causes a pulsed response in appropriate non-homogeneous magnetically-active wire arrays. See The Future of Chipless RFID www.idtechex.com

Bi-directional	Capable of operating from two directions. E.g. an RFID tag that can be written to and read for opposite directions.
BID	Baggage Information Database (air industry)
Biometrics	Technologies which enable people to be identified by their individual physical or behavioural characteristics. These characteristics can be based on an individual's signature, fingerprint, hand geometry, retinal eye pattern, voice or keyboard rhythm.
Biomimetics	The scientific study of the structure and function of biological forms in Nature. See the new report Smart Packaging www.idtechex.com
Bit	Bit is an abbreviation of binary digit, the fundamental building block of digital computer systems. A bit can either be a '1' or a '0'. Several bits, usually in groups of 8, make up binary numbers, which may represent an alphanumerical character, a value, a program instruction or other information. The memory capacity of a smart card is usually quoted in bits.
Bluetooth™	A technology aim to create a common standard for simple yet secure and reliable communication solutions through wireless connections, enabling wireless networks (WLAN). It was primarily intended for communication between mobile telephones, personal computers, speakers and microphones. The standard was founded by Ericsson in 1994 but later joined by Nokia, IBM, Toshiba and Intel in 1998 to form the Bluetooth Special Interest Group, which campaigns for further Bluetooth adoption. Today, there are often Bluetooth features on cellphones but, as yet, they are little used. Bluetag of Denmark combine Bluetooth and RFID in pendants used for locating children in theme parks etc.
BSE	Bovine spongiform encephalopathy, a progressive neurological disorder of cattle that results from infection by an unconventional transmissible agent, commonly referred to by the media as mad cow disease.
Byte	A byte is a group of bits, usually eight. As memory capacities increase, the capacity of chip cards is often quoted in bytes rather than in bits as in the past.

C

CCTV	Closed Circuit Television – surveillance cameras.
CD-ROM	Compact disc read-only memory.
CEN	Comité Européen de Normalisation (standards body).
CENELEC	CEN standards body for electrical systems.
CEO	Chief Executive Officer
CEPT	The European telecommunications and posts administration committee.
CLO	Chief Logistics Officer
CMOS	Complementary metal oxide semiconductor : one of several chip fabrication technologies. Its advantages for chip cards, tickets and tags are that it has a low power consumption, operates faster and is resistant to electronic noise. CMOS can operate over a wide range of supply voltages. This technology is in widespread use and recent inventions mean that it is now possible with the new ultra low cost printed transistor circuits that employ soluble polymer semiconductors because these are no longer confined to p type transistors. This is particularly significant for smart packaging. However, CMOS circuits are susceptible to damage by static

	electricity so care is required when handling them.
COO	Chief Operating Officer
CPG	Consumer Packaged Goods
Capacitive coupling	Contactless signal transmission by electrostatic effect, i.e. the capacitance of the (small) gap. A minority of contactless chip cards and tags use this principle, notably Motorola BiStatix process licensed to DNP, Flint Ink, Power Paper, etc and Cypak technology used in patient compliance monitoring blister packs. See The Smart Label Revolution www.idtechex.com
Capacity	The amount of data (bits or bytes) that can be programmed into a tag or smart package. This may represent bits available to the user or the total number of bits including those used by the manufacturer etc.
Capture field	Region of the interrogator field in which an RFID tag will operate.
Capture window	As above.
Cardinal Healthcare	One of the largest healthcare services companies in the US. has its own RFID smart dispensing trolley for its hospitals. See new report Item Level RFID www.idtechex.com
Chip Card	Cards with one or more microchips (integrated circuits) in them. See IC cards, memory cards, simple logic chip cards, smart cards and super-smart cards. See The Smart Label Revolution www.idtechex.com
Chipless tag	A tag without a microchip (integrated circuit). See The Future of Chipless Smart Labels www.idtechex.com
Chipless first generation	Chipless RFID tags are evolving in two stages. First has come those that are intended for closed, usually secure systems where non-conformance to standards is a positive advantage. The two big successes here have been Wiegand/Barkhausen electromagnetic wire arrays in HID contactless cards for secure access, where 80 million have been sold at about $2 each and acoustomagnetic foils forming 10 cent labels in 25 million AstraZeneca Diprivan syringes for error prevention. By contrast, the largest supply of one type of chip-based RFID tag into a single application has bee 30 million Innovision tags for Hasbro toys. Both of the chipless best-sellers store about 24 bits and can be interrogated at a few centimetres. The Diprivan application is error prevention by electronic handshake: the wrong drug or dose can not be dispensed. It completely eliminated such errors over the seven years it has been used and currently 4.5 million such labels are used yearly just on Diprivan. See The Future of Chipless Smart Labels www.idtechex.com
Chipless second generation	The second stage of chipless RFID, which can lead to sales of billions to trillions yearly, is its use in open RFID systems i.e. where many service providers are involved with any one system. This stage has been delayed not by lack of suitable technology but by the fact that the chipless proponents involved were undercapitalised, let the standards be written around more expensive chip tags and were often poorly managed, chasing the wrong opportunities. The standards in question were the operational standards defining frequencies, signalling protocols etc. Chipless labels have no problem with the numbering conventions, though versions with more than 24 bits have tended to be unnecessarily stuck in the laboratory. See The Future of Chipless Smart Labels www.idtechex.com

Chromogenic	Producing colour. See Smart Packaging www.idtechex.com and the monthly Smart Packaging Journal www.idtechex.com
Cipher	An encryption system that arbitrarily represents each character by one or more other characters.
Ciphertext	The encrypted, unintelligible text produced by a cipher.
Client	A computer connected to a network that requests services from another computer connected to the network.
Closed System	Physically Closed: A system in which relevant data regarding the object are stored in a common database, accessible via datalink by referencing the individual ID code. In traffic management, a parking or road transit control achieved by monitoring both entry and exit e.g. with RFID cards. Any transaction takes place on exit with charges based on time parked, distance travelled etc. Commercially Closed: A system, such as RFID, that is under the control of one owner or authority. In the plastic card arena, a closed system is sometimes referred to as one which involves only one card issuer and which does not need to interact with the cards of any other issuer. Closed systems may be for a single or multiple applications within those sites. They do not have a system operator that is independent of the service provider. See Open System and Open System Architecture. See Item Level RFID www.idtechex.com
Code	An encryption system whose components represent characters, words or sentences.
Computer Network	A system of two or more computers connected by communications channels.
Conditional	A statement in a segment or message directory of a condition for the use of a segment, a data element, or a component data element.
Contacted Chip Card	A chip card which communicates and receives power via metal contacts located on its surface.
Contactless Chip Card	Card which does not need to make physical contact with the read-writer in order to work because it passes electrical or magnetic signals through the air. Some operate only a few millimetres away from the reader; others work at many metres. The remote linking is either by capacitative or inductive coupling. More expensive but more reliable and sometimes more tamper-proof than contacted cards. The remote link is by either capacitative or inductive coupling. See The Smart Label Revolution www.idtechex.com
CRDA	Cooperative Research & Debt Agreements (US Military)
Cryptography	The enciphering and deciphering of messages using secret ciphers or codes.

D

Decryption	The process of converting encrypted data back into its original form so that it may be understood and/or processed.
Dedicated Network	A communications facility established for a specific purpose. Each remote terminal on the network is assigned to a specific termination point.
DB	Database
DES	Data encryption standard is a private key encryption algorithm, where the same key

is used for encryption and decryption. The key must be kept secret and distributed securely to maintain system security. DES has been adopted by the National Bureau of Standards and is used extensively in banking. Smart cards are available that can encrypt and decrypt DES messages internally.

DPM Defects Per Million

Diagnostics Diagnostics in the context of labelling and packaging is the use of devices that visually or electronically reveal a change of condition. Usually special inks or laminates are employed and conditions revealed can include:

- Unacceptable levels of bacteria (e.g. meat storage).
- Sterilisation process successful (e.g. medical disposables).
- Time/temperature excursion (high temperature short time or somewhat raised temperature for a long time). This may show food is cooked or vaccines have been properly refrigerated.
- Time elapsed (e.g. hair dye).
- Temperature (e.g. wine is cool).
- Tilt
- Shock
- State of charge of a battery.

The various forms of diagnostics can be in real time or historical, depending on the design of the intelligent packaging notably the type of ink or laminate used. More expensive, more accurate alternatives are just becoming available that are electronic.

See Smart Packaging, Electronic Smart Packaging and the monthly Smart Packaging Journal www.idtechex.com

Digital Pertaining to the representation, manipulation or transmission of information by discrete, or on-off, signals.

Digital paper Thin flexible transparent film having tiny "bichromal" plastic beads embedded in it that can be switched between contrasting colours such as black and white.

See Electronic Smart Packaging www.idtechex.com

Domain Name System The Internet's Domain Name System DNS allows Internet routing computers to identify where the pages associated with a particular Web site are stored. The DNS is used every time a Web site is accessed.

Dumb In the plastic card arena, this term is used to refer to any card, tag or token without any processing capability, i.e. it only stores information or units of value.

DUST Dual Use Science and Technology (US Military) e.g. sterilisation by UHF etc rather than high heat

E

EAN An association which manages a worldwide identification system and standards for communicating data for products, services, transport units, locations and assets. EAN develops and maintains international and multi-sectoral standards related to the identification system and its application in Automatic Data Capture and Electronic Commerce technologies. The global objective is to provide a common language to be used in national and international trade.

In 1974, manufacturers and distributors of twelve European countries formed a council to examine the possibility of developing a standard article numbering system for Europe, similar to the Universal Product Code (UPC) system already set in the

	USA by the Uniform Code Council (UCC). As a result a not for profit association called "European Article Numbering Association" (EAN) was created in 1997. The Head Office was established in Brussels, Belgium. The success of the EAN System led to the establishment of new Numbering Organisations in countries from all continents. EAN quickly acquired an International status and changed its name to "EAN International". Today, more than 550,000 companies worldwide use the EAN system through an international network of Numbering Organisations represented in over 90 countries. In addition, UCC's membership reaches 220,000 companies in the USA and Canada. EAN International was originally involved with the numbering and bar coding of products in the retail industry. The success in this sector led to other industries adopting EAN standards to meet their item identification needs. Health Care, Packaging, Transport, Publishing, Shoe, Electronics, Postal Services, Defense, are examples of sectors adopting the EAN system. EAN now partners with UCC ("EAN.UCC") and they are involved in the Electronic Product Code (EPC) and associated standards for The Internet of Things.
EAS	Electronic Article Surveillance e.g. anti theft radio tags. See The Smart Label Revolution www.idtechex.com
ECP	Electronic Compliance Package See proceedings of annual conferences, Smart Tagging and Smart Packaging in Healthcare and monthly Smart Packaging Journal www.idtechex.com
ECR	Efficient Consumer Response initiative.
EDI	Electronic data interchange: the electronic exchange between commercial entities (in some cases also public administrations), in a standard format, of data relating to a number of message categories, such as orders, invoices, customs documents, remittance advice and payments. EDI messages are sent through public data transmission networks or banking system channels. Any movement of funds initiated by EDI is reflected in payment instructions flowing through the banking system.
EEPROM	Electronically erasable programmable read-only memory: like EPROM memory, EEPROM memory retains its contents when no power is available and can be both read from and written to. Unlike EPROM, information stored in EEPROM memory may be rewritten as and when required. In chip card terms the memory cannot become full and the lifespan of the card is determined by other factors. It is also sometimes known as E2PROM or simply E2.Chip cards can have EPROM or EEPROM memory.
EID	Electronic Identification. Term used for RFID tagging of animals.
EID	Enterprise ID
EPC or ePC	Electronic Product Code. 'A numbering scheme that can provide unique identification for physical objects, assemblies and systems. Information is not stored directly within the code – rather, the code serves as a reference for networked (or Internet-based) information, in other words, the code is an "address" – it tells the computer where it should go to find information on the Internet.

The EPC requires relatively few parameters to determine the design:

- Number of bits – i.e. How much information is needed to provide a unique identity in every single product manufactured, sold and consumed in the global supply chain?
- Bit "partitions" – i.e. What is the best way to organise – or "break up" – the numbers/figures so that we achieve as many unique combinations as possible, while also expediting Internet searches? Consider this an exercise in determining the best "search hierarchy" – like a postal address – which goes from country to city, to zip code, to street, to house and individual

As the detail or level of the hierarchy increase, the speed and accuracy of the search will likewise increase, but the possible combinations of unique numbers will decrease.

See Item Level RFID www.idtechex.com

EPC and RFID

EPC (Electronic Product Code) is simply a number, typically from 64 to 256 bits long, that is being standardized so thousands of trillions of items in the world can be assigned a unique identification number, a unique EPC, which is the equivalent of an electronic bar code. This is vital so that everyone uses one type of system and not their own code – which would lead to great confusion because so many different people need to read the same tag. "Closed" systems – such as a library, use their own numbering system (i.e. not EPC) as books may only be read in that library and not all around the world. That is why we see many case studies of tags being used in small "closed" applications – they don't have to wait for standards, but tagging things on a large open infrastructure means there has to be just one way of identifying everything, in this case EPC. This requires standardization which in turn needs time for everyone to agree on the right way to structure the numbers – which was one purpose of the Auto-ID Center. Now this project is managed by the newly formed EPCglobal which will licence usage in a similar way to barcodes. The same organisations are involved with both – UCC and EAN. In the simplest terms, EPC is just a number.

RFID is the favoured medium used to transmit and read that number remotely, e.g. through packaging, or many tags at once for example. RFID systems don't have to use EPC, as in the library case and many others, but if they do the readers need to use the same type of database to determine what the EPC number is and which item it is connected to. This database is known as SAVANT.

Auto ID Center developed and researched the EPC and SAVANT and a few other software add-ons. It allowed all the sponsor members to agree on how the code should be structured. Companies joined the Center to have a say in how the items should be numbered. Now EPCglobal is standardizing it so people can use it like they do barcodes – companies pay UCC and EAN, the standardization organisations, to use a range of EPC numbers. The more EPC numbers you need (the more items you tag), the more you pay. The Auto-ID Center decided that RFID would be the medium to read EPC tags, but they did not determine the type of RFID system to be used – so people can use different frequencies, for example 13.56MHz and UHF, to read the same code.

See Item Level RFID www.idtechex.com

	Therefore EPC and RFID are complementary, but EPC is not the only way to do things. For example, RFID is really big in transport for contactless smart cards, and these were standardized a long time ago and use a numbering system that is completely different to EPC.
EPROM	Electronically programmable read-only memory: data stored in EPROM memory is retained when there is no power supply. Data can be both read and written but new data cannot be partially written over existing data. Usually the only way to do this is to expose the memory to ultraviolet light, thus erasing the entire contents, and then add the new information to the blank area. In a chip card this means that, when an EPROM card's memory is full, it is no longer of practical use as, for example, a prepayment card.
EMID	Electromagnetic Identification. Term coined by chipless RFID company Flying Null in the UK to distinguish its electromagnetic product from conventional silicon chip RFID.
ETSI	The European Telecommunications Standards Institute. ETSI has been active in the smart card field, building European standards where there are gaps in the ISO standards. ETSI card standards work is based on ISO standards where published.
Electric Field Coupling	"Efield" data transfer typically UHF or higher frequency e.g. a dipole "talking" to a dipole.
Electroactive polymers	Polymers that can change shape in response to electrical stimulation, of interest as artificial muscles and other smart devices. See Electronic Smart Packaging www.idtechex.com
Electrochromic material	A substance that changes colour or transparency when subjected to an electric current, as in the liquid crystal display of many calculators. See Electronic Smart Packaging www.idtechex.com
Electromagnetic coupling	"HField" use of a magnetic field as a means of transferring data or power. Usually a "coil" talking to a coil. Alternatively use of any electromagnetic transmission for data or power transfer. See The Smart Label Revolution www.idtechex.com.
Electromagnetic EAS and RFID	The electromagnetic EAS system creates a low frequency electromagnetic field between two pedestals at an exit or checkout aisle. The RFID equivalent returns a signal from a fixed or handheld interrogator. Frequencies between 70 Hz and 1 KHz are often used for electromagnetic EAS. The field is varied in strength and polarity, repeating a cycle from positive to negative and back to positive again. With each half cycle, the polarity of the magnetic field between the pedestals will change. Responding to the changing magnetic field created by the transmitter, the magnetic field of the tag material switches as the field strength varies past a particular point, positive or negative, during each half of the transmit cycle. This sharp change in the magnetic state of tag material generates a momentary signal that is rich in harmonics (multiples) of the fundamental frequency. Electronic signal processing techniques are used to verify that the harmonics are at the right frequencies and levels, and that they occur at the proper time in relation to the transmitter signal. If this is the case, an alarm is triggered.

	Electromagnetic EAS devices are the thinnest and fairly tolerant of bending and therefore the most suitable for thin packaging. However, they do not work with acoustomagnetic pedestals, the largest installed base and range is limited. They are the third most popular EAS technology and are losing market share. Electromagnetic EAS employs wire (e.g. ACS) or RF sputtered thin films of high permeability, low coercivity materials the same as that used for EAS (e.g. Flying Null). Flying Null uses the term Electromagnetic Identification EMID to distinguish it from mainstream RFID. See Item Level RFID and The Future of Chipless Smart labels www.idtechex.com
Electro-rheological materials	Materials that are fluids that solidify into a pasty consistency in the presence of an electric field (as molecules assemble in somewhat stiff chains along field lines), and then re-liquefy when that force is removed. See Smart Packaging www.idtechex.com
Electrostatic coupling	Inducing a voltage on a plate as a means of transferring data or power.
Encryption	Using ciphers to alter information before it is transmitted over a network. Encryption ensures, to the greatest extent possible, that messages cannot be read or altered during transmission.
Enzymatic hydrolysis	The use of an enzyme to convert starch into simple sugars; a stage in the production of ethanol
EPCglobal	The EPC standardization work is being conducted by EPCglobal, which is owned by UCC and EAN, responsible for standardizing barcodes. UCC and EAN were involved in the instigation of the Auto-ID Center, and the work completed by the Center is now being commercially standardized by them. EPCglobal will be funded by new sponsorship tiers, which will be necessary to be actively involved in the standardization process. EPCglobal will initially finance the Auto-ID Labs, but then they will seek their own sources of funding. Programmes within Auto-ID Labs will look into further application areas, as much of the work finally focused around the supply chain and retailing, but now application areas under consideration include pharmaceutical and baggage tagging. For more information, the EPCglobal website is www.epcglobalinc.org See Item Level RFID www.idtechex.com
Envision America	Envision make RFID tag systems that make pots of tablets talk to patients. Works with Zebra, a leading manufacturer of label printing machinery
Error rate	Number of errors per number of transactions.
F	
FMCG	Fast Moving Consumer Goods
Factory programming	The programming of information into a tag as part of its manufacture. The result is a read only tag.
Field programming	Programming a tag after it has left manufacture e.g. by the user. This is usually done before the tag is attached to the object to be identified. Field programming permits data specific to the application to be recorded in the tag. Some tags are made so that part of the memory is dedicated in the factory and part in the field.

Field protection	The ability to limit the operations which can be performed on portions or fields of the data stored in the tag.
Flash memory	An advanced type of EEPROM memory: it is a high density, low power consumption, rewriteable non-volatile medium used in some modern chip cards and computers.
Flat panel antenna	Flat conductive sheet aerial on tag or interrogator, usually made of metal plate or foil.
Frequency	The number of times a signal executes a complete excursion through its maximum and minimum values (cycle) and returns to the same value.

G

GAV	(US Military) Global Asset Visibility
GB	Gigabyte. This is used to describe a memory size of 1,073,741,824 bytes. A byte is eight binary digits or 'bits'. 1 GB equals 1,024 megabytes (MB).
GCI	Global Commerce Initiative.
GHz	Gigahertz. The Hertz is the unit of frequency – it means cycles per second. 'Giba' in engineering means one thousand million – rather less than the 'giga' used to describe memory size in some computers! For the confused, the reason for the difference is that in computers binary codes are used to contact, or 'address' each stored byte of data. The number of different codes on 'addresses' that can be generated by binary numbers is calculated from two raised to the power of the number of bits in the code. So 2-bit code provides two to the power of two which equals four addresses and so on. The closest we can get to one thousand million is to use a 30-bit binary code which yields 1,073,741,824 – the 'giga' used to describe computer memory capacity.
GIS	Goods Information Server. See Electronic Smart packaging www.idtechex.com.
GPRS	General Packet Radio Service: a radio technology for GSM networks that adds packet-switching protocols, shorter set-up time for ISP connections, and offer the possibility to charge by amount of data sent rather than connect time. GPRS promises to support flexible data transmission rates typically up to 20 or 30 Kbps (with a theoretical maximum of 171.2 Kbps), as well as continuous connection to the network. A 2.5G enhancement to GSM, GPRS is the most significant step towards 3G, needing similar business model, and service and network architectures. GPRS started to appear in some networks during 2000. The European Commission ParcelCall project envisages using it in conjunction with RFID for parcel tracking. See Electronic Smart packaging www.idtechex.com
GPS	Global Positioning System, by satellite. Sometimes used in conjunction with RFID. See The Smart label Revolution www.idtechex.com
GSM	Global system for mobile communications. The digital system for mobile phone communications. For computer communications, GSM offers a higher rate of data transfer (9,600bps) compared with analogue mobile phones (4,800bps). Portable PCs can connect to a mobile phone by using a PCMCIA communications card.
GTAG™	"Global Tag", a standards body that was run by UCC and EAN to develop standards for RFID smart labels and tags, for use in logistics. Now subsumed in other work. (ISO 18000)

GTS	Goods Tracing Server. See Electronic Smart Packaging www.idtechex.com.
H	
H Field	See Electromagnetic Coupling
I	
IC	Integrated circuit. Arrays of electronic components such as transistors, diodes and resistors made with their interconnects on or in a single piece of semiconducting material such as silicon. This can save cost, improve speed of working and improve reliability.
IC Cards	Integrated circuit cards: the term favoured in Japan, Denmark and elsewhere to describe chip cards.
ID	Identification, for example the identification number in an RFID tag.
IEC	International Electrotechnical Commission.
IP	Intellectual Property
ISO	International Standards Organisation. A United Nations agency which coordinates and publishes standards of product performance.
IT	Information Technology
IWG	Internet Working Group
ID filter	Software that compares a newly read ID with that in a database or set.
In use programming	New data or revisions to data being recorded e.g. on an RFID tag in use. Otherwise known as field programming.
Inductive Coupling	This technique is used in many contactless cards in order to deliver power to the card and to allow it to communicate with the outside world. Same technique used to interrogate early types of in-car tag. A coil is embedded within the surface of the card or the road and a card is placed in or connected to the read-write unit. When the current is passed through one coil, say the read-write unit, magnetic field is created and, if the second coil, say in the contactless card, is bought close enough to it, this magnetic field leads to current being delivered to that coil as well. Once this occurs, the card has sufficient power to function and data can be exchanged between the card and the read-write unit.
Infineon	See The Smart Label Revolution www.idtechex.com Split off from Siemens several years ago, it is one of the world's largest chip manufacturers and the largest supplier of chips for smart cards. Researching oligomer TFTCs.
Information Mediary	Small Canadian company making RFID/patient compliance blister packs and plastic bottles and RFID electronic time temperature labels.
Insult Rate	Percentage of rejections as false of what are actually valid inputs, e.g., in biometrics.
Intelligent packaging	Intelligent packaging is a term that is not used as often as smart packaging. Sometimes it is used as synonymous and sometimes as a subset of smart packaging, usually limited to features that respond to circumstances. Sometimes people constrain their use of the term intelligent packaging to electronic features alone.

	See Electronic Smart Packaging and the annual US conference Intelligent and Smart Packaging www.idtechex.com
Intermodal containers	Standard oblong freight containers the size of a truck that are used for road, rail and sea transport. See Item Level RFID www.idtechex.com
Internet of Things	Term coined by MIT Auto ID Center for things "talking" electronically to thing over the Internet. See EPC and EPCglobal
Interrogator	Electronic device that remotely interrogates the data on an RFID tag and may or may not be able to rewrite it, i.e. an interrogator may be a reader or a read-writer.

J

JTAV	Joint total asset visibility. In April 1992, the US Military decided to pursue TAV with considerable investment. To date, about $600 million has been spent on the core aspects of this program. It had to involve all arms of the service so the term Joint Total Asset Visibility (JTAV) was coined. It is not confined to the modest level of RFID tagging but encompasses all existing data acquisition methods as updating proceeds. JTAV is the Defense Department's automated information capability for tracking equipment, personnel and supplies. It gives increasingly pervasive information on location, movement, status, identity of units, personnel, equipment and supplies. There is an overarching logistics strategy to support global end to end distribution and visibility capability, to coin the words of the US Military. The Deputy Under Secretary of Defense for Logistics (DUSD(L)), as the Secretary of Defense's Principal Staff Assistant (PSA) for logistics, designated the Army as Executive Agent to lead the initiatives for further development and implementation of the JTAV program. In 1995, The Army Deputy Chief of Staff for Logistics (DCSLOG) established the JTAV Office to provide management of the effort. In 1998, the DUSD(L) reassigned the JTAV Program Executive Agency to the Defense Logistics Agency (DLA). The DUSD(L) chairs the JTAV Council which consists of the Joint Staff J-4, Joint Staff J-1, the Service Logistics Chiefs, Director Defense Logistics Agency (DLA), Director Defense Information Systems Agency (DISA) and Deputy Commander-in-Chief (DCINC) United States Transportation Command (USTRANSCOM). The JTAV Office operates as a joint organization with guidance provided by the DUSD(L) to the Executive Agent. The JTAV Office is responsible to ensure a JTAV capability is provided throughout the DOD by ensuring JTAV functional requirements are satisfied by DOD-wide automated information systems. It focuses on providing asset visibility in-storage, in-process and in-transit to help optimise DOD's warfighting capability and the ability to conduct operations other than war. The JTAV Office also evaluates the design, development, integration, and implementation of logistics processes, technologies and systems to achieve these requirements. Using active RFID tags (i.e. With battery for long range etc.), assets are now monitored in 40 countries at 400 nodes at seaports, airports, rail terminals and army bases. The JTAV Office ongoing mission is to ensure that the required level of TAV capability

	is provided to the Combatant Commanders. This includes subordinate Joint Task Force (JTF) Commanders, the Services and DOD activities. The focus of the JTAV Office is on executing the JTAV Implementation Plan in support of this. The JTAV Office performs the central role as the functional integrator. It serves as the proponent for JTAV and will lead and manage the Joint TAV effort DOD-Wide. See Item Level RFID see www.idtechex.com
JTAV database	The Joint Total Asset Visibility program revolves around a centralized database that allows commanders to have total visibility over Army and DOD assets that are stored or in-transit in the supply pipeline. The visibility data is taken from several interrelated databases : Global Transportation Network (GTN), Logistics Information Processing System (LIPS), Inventory Control Points Automated Information Systems (JLOG), The Standard Army Retail Supply System (SARSS), The Standard Property Book System-Redesigned (SPBS-R), and the Defense Automatic Addressing System Center (DAASC). The GTN is a command and control system that aids the United States Transportation Command's (USTRANSCOM) visibility of material in transit. The LIPS is the central point for information on all ICP-managed assets. The JLOG helps commanders manage assets to improve utilization, to cross level and to redistribute parts. The SARSS provides retail level inventory updates to the Army Total Asset Visibility (ATAV) through DAASC. The ATAV major end item information is updated by SPBS-R through the Continuing Balance Asset System-Expanded (CBS-X). Most of these databases are at the wholesale level. However, SARSS is used by supply support activities at the Direct Support (DS) level and SPBS-R and TAV are used at the Property Book level. See Item Level RFID www.idtechex.com
K	
Kb	Kilobit. This is 210 (1024) bits—not simply 1000 bits as the term suggests. In computing, the term kilo suggests 210 rather than 103.
KB	Kilobyte. This is 210 (1024) bytes.
Key	A secret value used in encrypting algorithm known by one or both of the communicating parties; it is similar to a combination number for a vault. A symmetric key is used to control both the encryption and decryption processes. Public key encryption uses a pair of different values to control a related encryption and decryption process: the sender encrypts with the receiver's public key, and the receiver decrypts with his/her private key. A session key uses a unique key for a simple data exchange or set of data exchanges.
Key Management	The process by which keys are distributed to usage points while kept in a protected form by encryption.
Key-Distribution Centre	A communications facility in a single-key encryption network that translates a session key encrypted by a message.
L	
LAN	Local Area Network.
LC	Inductor with capacitor in parallel. The basis of Swept RF EAS tags.
LC Array	Several LC elements constituting an RFID version of swept RF EAS.

	See The Future of Chipless Smart Labels www.idtechex.com
LCD	Liquid crystal display.
LED	Light emitting diode.
Laminar	Thin flat electronic circuits, usually flexible.
electronics	See Electronic Smart Packaging www.idtechex.com
Level	A means of indicating the hierarchical and processing order of segments and groups in a message.

M

MAP	Modified Atmosphere Packaging
MIV	Mobile Inventory Vehicle. A vehicle equipped with a system such as RFID for locating tagged vehicles, inventory etc for the purpose of inventory control.
MLS	Mobile Logistics Server. See Electronic Smart Packaging www.idtechex.com.
ms	Millisecond. One thousandth of a second.
Magnetic Stripe Cards	Cards with a magnetisable material in or on them (as found on the world's most popular credit, debit and prepayment cards). ISO standard magnetic stripe cards have three tracks of data, the first being assigned to the airline industry – accepts alphanumeric entries, the second to financial transactions – numeric content only, and the third being a rewriteable track designed for off-line magnetic stripe based transactions; it is rewritten each time. Magnetic stripe cards carrying non-standard stripes and multiple stripes are also used in large numbers for access control and storing value. Magnetic stripes are also applied to cardboard tickets.
Magnetostriction	A change in dimensions of a ferromagnetic material that is subjected to a magnetic field. See Item Level RFID www.idtechex.com
Mandatory	A statement in a segment or message directory which specifies that a segment, a data element, a composite data element or a component data element must be used.
Memory Card	A chip card without processor, i.e. not a true smart card. Also used for data storage devices of the type being standardised by the American PCMCIA and the Japanese JEIDA organisations. This second type of card was originally a memory-only storage device in the shape of a thick bank card, but has now evolved to include, for example, receiving faxes.
MEMS (Electronic)	Micromachined Electromechanical Systems are microscopic machined devices moved by electricity and usually repeated in large numbers across a surface for some purpose
MEMS (Medical)	Medication Event Monitoring System. A patient compliance monitoring system by Aardex Switzerland/ US using clocks in vials. MEMS is a registered trademark.
Metabolite	A product of metabolism; a substance produced by metabolic action, as urea. The decomposition signatures of foodstuffs.
Metadata	Data about data, describing the structure and format of the data.
Microencapsulation	A process by which tiny parcels of a gas, liquid, or solid active ingredient are packaged within a second material for the purpose of shielding the active ingredient from the surrounding environment.

	These capsules, which range in size from one micron (one-thousandth of a millimetre) to seven millimetres, release their contents at a later time by means appropriate to the application.
Micromuscle AB	Swedish company developing polymer actuators for biomedical applications. They can be in the form of films. See Electronic Smart Packaging www.idtechex.com
Misread	The condition that exists when data presented by the interrogator is different from the data in the tag.
Modulation	Ways of altering the carrier electromagnetic wave in order to transmit a signal efficiently. Examples are amplitude modulation AM (data contained in amplitude of carrier), phase modulation PM (data contained in changes of phase), frequency modulation FM (data contained in changes of frequency), Frequency shift keyed FSK (data contained in changes between two frequencies of carrier), pulse duration PDM (data contained in the duration of pulses), pulse position PPM (data contained in the position of the pulses relative to a reference point), continuous wave CW (data contained in a carrier which is switched on and off). In some cases, it is best to use a different modulation technique to and from a tag.
MRE	US Military. Meals Ready to Eat (rudely called Meals Rejected by Everyone in the early days). Often employ "active packaging". See Smart Packaging www.idtechex.com
Multipacks	Packs containing many, usually packaged, products. Usually a form of secondary packaging.
Multi-Purpose Card	Cards that operate in more than one applicational mode such as credit, debit, prepay, secure access, ID. Particularly used where financial and non-financial functions are combined.
N	
O	
OFET	Organic Field Effect Transistor See Electronic Smart Packaging www.idtechex.com
OLED	Organic Light Emitting Diode displays. A form of laminar electronics The diodes in these displays emit light when a voltage is applied to them, and can be selectively turned on or off to form images on the screen. The devices use organic not silicon semiconductor materials. See Electronic Smart Packaging www.idtechex.com
OSI	Open Standards Institute
ONS	Object Naming Service, or ONS, 'tells computer systems where to locate information on the internet about any object that carries an EPC (electronic Product Code). ONS was developed at the Massachusetts Institute of Technology by Dr David Brock, Professor Sanjay Sarma and Joseph Foley. ONS is similar to – and (in part) based on – the Internet's existing DNS (Domain Name System), which allows Internet routing computers to identify where the pages associated with a particular Web site are stored. The DNS is used every time a Web site is accessed. The ONS will be used every time information is needed about a physical object. It is likely that the ONS will be many times larger than today's DNS. Although conceptually simple, designing

	ONS was a challenge. The system must be capable of quickly locating data for every single one of the trillions of objects that could potentially carry an EPC code in the future. The ONS must serve as a lightning-fast post office that, on a daily basis, receives and delivers millions (if not billions) of letters.' See Item Level RFID see www.idtechex.com
Omnidirectional	Ability of a tag to work in any direction.
Optical Memory	In the context of cards and tickets, this means a raster scanned optical memory stripe invented by Drexler Corporation and licensed to Canon and others, its own version being branded LaserCard. RFID cards for national ID in Italy and China have an optical memory stripe because it is not yet cost effective to have the one megabit or more of memory for biometrics etc on the chip.
Off-line	A mode of operation that does not require a network and/or third party authentication.
On-line	A mode of operation that does require a network and/or third party authentication.
Open System	In computing, conforming to standards that facilitate different manufacturers' computers and allied equipment interconnecting widely. In transport, an open system can mean that not all entrances and exits have barriers. For example, for RFID i.e. contactless smart cards to be used it is usually necessary to install automatic barriers at all entrances and exits to stations or all entrances to buses.
Open System Architecture	In an open system, different hardware, application, operating systems and user interfaces can coexist and interact because each part meets the standard that governs communication and data exchange. EPC and barcoding systems are intended to be open so any service provider can use them. The Hitachi Mew Solutions numbering system for its RFID tags is intended to be closed for maximum security, any tranche of numbers that it issues being intended for one service provider.
Operating System	A complex set of programmes that control, assist and supervise all other programmes run on a computer.
Organoleptic	Relating to the senses (taste, colour, odour, feel). See Smart Packaging www.idtechex.com
P	
PCM	Phase Change Materials, are compounds which melt and solidify at certain temperatures and in doing so are capable of storing or releasing large amounts of energy. The temperature at which the transition from solid to liquid occurs is the melting point or phase change temperature. See Smart Packaging www.idtechex.com In electronics, it means Pulse Code Modulation
PCMCIA	Personal Computer Memory Card International Association. A committee which has produced the standard format for the credit card sized plug in memories, modems, sound cards and now RFID tag interrogators that are used with portable computers.
PDA	Personal Digital Assistant.
PEDs	Printable Electronics and Displays
PIN	Personal identity number given to and associated with a user and keyed in when gaining access to ATMs, etc.

PhRMA	Pharmaceutical Research and Manufacturers of America.
PMR	Programmable Magnetic Resonance. An acoustomagnetic technique used for chipless RFID tags. Origin Scientific generics UK.
Packaging	Packaging is the covering of merchandise or assets for protective, promotional and other reasons.
Parity	A bit that indicates whether the number of ones in a bit string is odd or even.
Passive tag	In electronics this means either unable to generate its own signal, therefore has no power supply (e.g. passive RFID tag) or an electronic component that cannot amplify signals and/or obeys Ohms Law (e.g. resistors or capacitors). See The Smart Label Revolution www.idtechexcom
Pathogen	A disease-causing agent, such as viruses and bacteria. See Smart Packaging www.idtechexx.com
Pentacene	Organic oligomer used as the semiconductor in thin film field effect transistors. Needs vacuum processes because it is insoluble but gives higher charge carrier mobility than the soluble organic semiconductors that can be printed. This means that the transistors can work at higher frequency and be used in more applications technically, though cost is a challenge. See Electronic Smart Packaging www.idtechex.com
Personal authentication	Techniques used to authenticate an individual (i.e., validate an individual's unique identity) by testing for knowledge of secret codes or unique physical traits.
Personal identification number (PIN)	A unique number used to identify a customer when using credit and debit cards in ATMs, etc. A PIN is normally four-to-six digits long and is to be kept secret by the user.
Photochromic	Changes colour with the intensity of incident light, for example, as found in sunglasses that darken in sunlight.
Photoinitiator	An agent that initiates, under the action of light, certain chemical transformations and is consumed.
Photonic crystal	A microstructured material is one that is structured on the scale of the optical wavelength. A diffraction grating is a simple example. If the structure is periodic – regularly repeating – then the material is called a "photonic crystal".
Photo-oxidation	The mechanism by which ultraviolet light reduces organic carbon to carbon dioxide. If halogenated organics are present, both CO2 and mineral acids can be formed. See Smart Packaging www.idtechex.com
Piezoelectric	A material that generates an electric charge when mechanically deformed. Conversely, when an external electric field is applied to piezoelectric materials they mechanically deform.
Polyfluorenes	Used in thin film light emitting diodes and thin film solar cells as the active element.
Polythiophenes	Organic materials used to print field effect transistors and electrochemical electronic components. See Electronic Smart Packaging www.idtechex.com
Polyvinyl-enephenylene	Used in thin film light emitting diodes and thin film solar cells as the active element.
Power levels	In RFID, the levels of power radiated from an interrogator or tag, usually measured

in volts/ meter.

Primary packaging Packaging designed to come into direct contact with the contents. Primary packaging is an integral part of a product : the outer case of a battery, the packet of seeds or the whisky bottle are examples.

Probiotics Live microorganisms which when consumed improve health and well-being by improving the properties of the resident microorganisms.

PML Product Mark-up Language, or PML, is a standard "language" for describing physical objects in EPC systems. It is based on the extensible Mark-up Language (XML).

Today, HTML (Hyper Text Mark-up Language) is the common language on which most websites are based, allowing individuals to surf the Internet from their desktops. Where HTML tells a computer how information should be displayed (e.g. what colour and size it should be) – XML goes a step further, telling the computer what kind of information it is viewing (e.g. an address or a telephone number). The PML will go even further, building in layers of increasingly specific data in order to describe physical objects, their configuration and state. In the end, PML:

- should translate or contain static data such as dosage, shipping, expiration, advertising and recycling information
- should provide instructions for machines that "process" or alter a product, such as: microwaves, laundry appliances, machine tools and industrial equipment
- may need to communicate dynamic data: information that changes as a product ages or as it is consumed, such as: volume, temperature, moisture and pressure
- may need to include software, or programs, which describe how an object behaves, for instance: a PML file may contain the program which describes how fast the tyres on your car will wear before they need to be replaced, or how fast an object
- may burn in case of a fire

See Item Level RFID www.idtechex.com

Programmability In order to be the electronic identifiers of specific objects, RFID tags must have their identity or other data entered into them. This capability is called programmability.

Programmer Some RFID tags can have their contents changed by electronic equipment nearby or connected to them. This equipment is called a programmer.

Protocol A specified procedure or process used to achieve a specific and common result, such as a network communications message format.

Proximity sensor A sensor that detects if something of a defined type is nearby.

Public Key System Cipher that employs a pair of mathematically related keys, one that is public knowledge within the computer network, the other known only to its owner. The sender uses the receiver's public key to encrypt data, which may be decrypted only with the related private key.

R

RFAIS Radio Frequency Automatic Identification Systems.

RFID Radio frequency identification. Use of small devices that can be electronically identified (and sometimes their data changed) at a distance without line of sight. Although radio is typically defined as 300 Hz to 300 MHz, nowadays the term even encompasses tags interrogated at 100 Hz and others at microwave frequencies (GHz).

See The Smart Label Revolution www.idtechex.com

RSA	A public-key cipher for commercial data that is based on the products of prime numbers; the initials stand for Rivest, Shamir and Adleman, the system's designers. Regarded as more secure than DES, when properly employed.
Range	The distance at which a successful read or write can be performed.
Read	The decoding, extraction and presentation of data from formatting, control and error management bits sent from a tag.
Read-Access	User's authorisation to read information stored in a computer.
Read rate	The maximum rate at which data can be read from a tag expressed in bits or bytes per second.
Readability	The ability to extract data from a tag, often under less than optimal conditions.
Reader	Device containing the digital electronics that extracts and separates information from the format definition and error management bits of RFID tags.
Read writer	An RFID interrogator that can also write data remotely onto an RFID tag.
Remote	A transfer mode that, among other things, allows payment transactions to be conducted over public networks between two or more parties that are physically separated.
Remote Magnetics	Principle of chipless RFID and EAS smart labels that use magnetic properties of
RM	materials instead of electronic circuits in the tag.
	See The Future of Chipless Smart Labels www.idtechex.com
Reprogrammable	Ability to alter data on a tag while it is attached to the object it identifies. Usually this can be achieved remotely even if the tag is moving.
Retortable	Capable of processing in a retort at temperatures above 100C
RTLS	Real Time Location System. Superset of RFID

S

SAVANT	RFID readers need to use the same type of database to determine what the EPC number is and which item it is connected to. This database is known as SAVANT. Auto ID Center developed and researched the EPC and SAVANT and other enabling software for the EPC system. It allowed all the sponsor members to agree on how the code should be structured.
	See Item Level RFID www.idtechex.com
SAW	Surface Acoustic Wave. In RFID, a phenomenon where radio waves captured by an antenna are converted by an interdigital transducer into acoustic waves passing across the surface of a piezoelectric material. These can then be reflected by deposited patterns, returning to the transducer at different times, representing bits of data and retransmitted. This form of SAW device is a read only RFID tag. It is "chipless" and has potential cost and performance advantages over chip RFID tags.
SVC	Stored Value Card, known as an electronic purse in Europe. A card that stores a notional value of money that is gradually spent down at each electronic transaction made using the card. A replacement for cash. Term usually therefore refers to a stored value card that can be used with more than one service provider.
Scalping	Removal of desirable flavour components of a food or beverage in contact with plastic packaging materials.
Scanner	Part of an RFID interrogator, consisting of antenna, transmitter and receiver

	electronics. Addition of a microprocessor and additional digital electronics would usually make it an interrogator (reader or read-writer).
Secondary packaging	Packaging designed to contain one or more primary packages together with any protective materials where required.
Segment	A pre-defined and identified set of functionality related data elements values which are identified by their sequential positions within the set. A segment starts with a segment tag and ends with a segment terminator.
Segmental numbering schemes	Barcode numbering schemes are segmented for better accuracy and data handling. Schemes for large and ultra large numbers of RFID tags use segmented numbering, to some extent mimicking barcodes. For example a barcode numbering scheme may involve four tranches of numbers respectively representing manufacturer, type of product etc and the EPC RFID numbering system mimics this with a far larger choice of identities.
Sequential numbering systems	Sequential numbering systems simply allot numbers in sequence such as 1,2,3,4 ... They are usually used in closed systems. Contrary to popular understanding, the UCC EAN segmented numbering systems can be linked compatibly to segmental numbering systems.
SHOT	Serious Hazards of Transfusion (UK monitoring project)
Shrinkage	Theft by staff or customers and misplacement or damage to products before sale. See The Smart Label Revolution www.idtechex.com
Simple Logic Chip Cards	Unlike the simplest memory chip cards these are able to perform specific application functions beyond the simple decrementing of value or units and have their contents protected by a PIN. Unlike smart cards, they cannot process the information stored on them. Their operation is governed by hardwired logic. They are less expensive than full microprocessor-equipped cards but are not so flexible. They are used in some prepayment cards as a good compromise of cost and security.
Smart and Secure Tradelanes (SST)	Major RFID systems, modelled on the US JTAV military system, are now being installed in civilian logistics systems. The largest recent example, initiated in mid 2002, addresses sea containers in the context of the new terrorism. Over 17,000 sea containers, carrying more than 80 per cent of US imports, arrive daily at US seaports, often located near major cities and industrial centers. The initiative aims to enhance the safety, security and efficiency of cargo containers and their contents moving through the global supply chain into US ports. Driven and initially funded by industry, this initiative called "Smart and Secure Tradelanes" (SST), is focused on container security and tracking and will be built on existing infrastructure and technologies that are both proven, available for immediate deployment, open and adaptable to enable integration of new "best-of-breed" technologies as they emerge. The industry-driven SST initiative will demonstrate the principles of the US Customs Container Security Initiative (CSI), Customs-Trade Partners Against Terrorism (C-TPAT), and the US Department of Transportation's Transportation Security Agency's (TSA) maritime security initiative, such as Operation Safe Commerce. Implementation of SST began immediately and was operational by year-end. It

involves automated information technology infrastructure linking ports such as Singapore, Rotterdam and Hong Kong with major US ports such as Seattle/Tacoma which is the first domestic port to rollout.
As in the military, the system improves the tracking and security of shipments coming into the United States through electronic event-driven alerts, anti-tamper systems, virtual inspection and authenticated audit trails. The TAV network is built on existing US and international standards and on the Universal Data Appliance Protocol (UDAP), which allows open "plug and play" integration of automatic data collection devices, such as RFID and GPS, along with sensors, scanning and biometric systems.
Savi Technology report that, initially, the SST rapid deployment implementation calls for an integrated security and container security system to register individuals, authorize roles, and to capture tracking a security events throughout the supply chain. Working with shippers, carriers, service providers, foreign and US port terminal operators, containers will be tracked and automatically authenticated from the point of manufacturing, port of loading, transhipment port and to final discharge in the US. SST, which will work in close coordination and consultation with government agencies, will develop and test potential auditable security standards for maintaining secure ports, shipping facilities and container tracking and security.
See Item Level RFID www.idtechex.com

Smart Cards Chip cards which have an onboard CPU (central processing unit), which is able to perform functions on the data stored in it. Microprocessor cards. Some journalists and manufacturers have widened the term to include all chip cards.

Smart packaging Smart packaging has no official definition but it is a commonly used term. It refers to relatively new packaging features that go beyond simple changes of shape or colour, alphanumerics, graphics, barcodes or better inactive protection. The heart of the subject is responsive features such as coverings that let certain gases out and other gases in or radio tags that return a signal when interrogated electronically. However, some would include modern forms of anticounterfeiting or antitamper feature in the definition.
See Smart Packaging and the monthly Smart Packaging Journal www.idtechex.com

Sol-gel A versatile solution process for synthesising inorganic materials, involving the transition of a system from a liquid "sol" (mostly colloidal) into a solid "gel" phase.

START Safer Transfusion with Advanced RFID Technology (US)

Subset An extract of a message type for use within one industry or application. The subset usually indicates only those segments, elements and code values needed by the industry or application.

Super Smart Cards Cards to ISO dimensions with their own keyboard, display and battery, can act as completely self-contained units without the need for a terminal. Their high level of complexity, however, makes them extremely expensive, they are not currently used in road pricing, or much else for that matter.

Superhydrophobic Extreme water-repellence, where droplets of water on a slightly sloping superhydrophobic surface bead up and roll off without a trace. Contact angles are

considerably greater than 140 degrees and in some instances may be as large as 170 degrees.

Susceptor

A metallic patch attached to microwaveable packages of food in which radiant energy produced in the patch by microwaves helps cook the food, often by browning its surface.

Swept RF EAS and RFID

Like the other two EAS technologies swept-RF also uses a transmitter to create a surveillance area where tags and labels are detected. However, the transmitter sends a signal that sweeps frequency, a typical range being from 7.4 to 8.8 MHz.

The transmitter signal energizes the swept-RF device which usually consists of a flat circuit containing a capacitor and an inductor (a printed or wound coil) both of which store electrical energy. When connected together in a loop (i.e. in parallel), these components pass energy back and forth (resonate). The resonant frequency is chosen by matching the storage capacity of the coil and capacitor. The tag responds by emitting a signal that is detected by a receiver. Accordingly, sweeping frequency picks up each differently specified inductor – capacitor (LC) pair, one at a time.

In addition to the small tag signal, the receiver also responds to the much larger transmitter signal. By detecting a phase difference between these two signals, and certain other properties of the tag signal, the receiver recognises the presence of a tag and generates an alarm, without being confused by other electronic devices in the neighbourhood.

Swept RF EAS is supplied by Checkpoint, world number two in EAS and many other companies including Lintec and Miyake in Japan and Nedap in The Netherlands. Not all systems are compatible, Though the tag designs are very similar and there is common cause for an interoperable standard. This is of particular interest in Europe and Japan.

Swept-RF is the second most popular EAS technology being of reasonable range and cost, fairly tolerant of bending and of thickness that is intermediate between magnetoacoustic and electromagnetic tags. It is suitable for most packaging.

About five other companies make RFID i.e. multibit versions of Swept RF with modest commercial success.

See The Future of Chipless Smart Labels www.idtechex.com

Syntax rules

Rules governing the structure of an interchange and its functional groups, messages, segments and data elements.

T

TAV

Total asset visibility. The quest to know the position and status of items of interest at all times. Programs that largely achieve this – usually based on RFID with or without other inputs.

In the Gulf war, the US military had to open 25,000 containers just to find what was in them. The paper labels and manifests had been destroyed by sand and by handling. This was clearly a very serious and mission-critical failure of " asset visibility " and it is one of the things that has led the US military to become one of the most energetic pursuers of so called " Total Asset Visibility, TAV ", the dream being to know the location and status of everything in real time and at all times, right down to the

	cheapest, least-important consumable. There are obvious potential benefits. They include less danger, greater effectiveness, and lower costs. Less manpower is needed and tasks can be deskilled. However, in many situations TAV, or some progress towards it, can make new things possible. For example a rapid response force may be effective in some distant land when it was previously impossible to mount an operation in the necessary timescale. Manufacturing industry, the medical services and many other organisations are keenly interested in TAV for reasons that include competitive advantage, service improvement, and the need to survive on slashed budgets. We shall see that many of these organisations need to develop the concept of the Internet of Things to achieve these objectives. See Total Asset Visibility www.idtechex.com and the monthly Smart Labels Analyst www.idtechex.com
TCP/IP	Transmission Control Protocol over Internet Protocol. An industry standard set of rules which allow different types of computer to communicate with each other over the internet.
TFE	Thin Film Electronics, a subsidiary of Opticom ASA in Sweden which develops non-volatile thin film electronic polymer memories. One type is on microchips and the other is on low cost flexible polymer film
TFTC	Thin Film Transistor circuit such as an OFET See Electronic Smart Packaging www.idtechex.com
TTI	Time Temperature Indicator. Device ,such as a smart label, that indicates if a product has exceeded a defined combination of time and temperature by changing colour or an electronic device that records the temperature as a function of time See Smart Packaging www.idtechex.com
Tag	A unique identifier for a component. This usually consists of some electronics containing a unique digitally encoded number and a means whereby the number can be read remotely. Tags can be read only or read-write and some are "killable" i.e. can be permanently disabled from a distance See The Smart Label Revolution www.idtechex.com
Tertiary packaging	Packaging designed to facilitate handling and transport of a number of sales units or grouped secondary packs in order to prevent physical handling and transport damage. Tertiary packaging usually encloses many secondary packages for transit, crates air ULDs and intermodal containers being examples.
Transdermal	Entering the bloodstream by absorption through the skin. See Iontophoresis See Smart Tagging and Smart Packaging in Healthcare www.idtechex.com
TREAD Act	US legislation requiring recording/reporting of identification codes of vehicle tires for safety i.e. to ensure that the right tire is on the right vehicle. Transportation Recall Enhancement Accountability and Document (US) Act. The tyre is linked to the Vehicle Identification Number (VIN). A recording requirement that has the effect of getting RFID into tyres. This is best achieved with RFID tags embedded in the tyres at manufacture e.g. 125.135Khz, 13.56Mhz or UHF

U

Ubiquitous ID Center	A standards group in Japan promoting an alternative to EPC. Apparently, the motivation includes what it perceives as US dominance of EPC and the restricted nature of the EPC concept. uID can even be used to "tag" lines of software code, they say. uIC is backed by 170 companies, nearly all of them Japanese. The center expects to have compliant tags available for purchase in 2004.
UCC	Uniform Commercial Code. North American standards body for barcodes and other item identification. See EAN for partnership.
UIC	Ubiquitous Identification Code, e.g. with barcodes
UID	Unique ID
ULD	Unit Load Device (air conveyance)
UMTS	Universal Mobile Telecommunications System. UMTS is a future mobile communications system which, among other features, will offer direct connection between terminals and satellites. UMTS is one of the ITU's proposals for technologies for world standards for 3rd generation mobile communications (IMT-2000).

V

Vehicle Identification Number (VIN)	Legal requirement of vehicle identification in the US.
vCJD	Variant Creutzfeldt-Jakob Disease, a rare brain disorder identified in humans, and strongly linked to BSE.
Viscoelastic	A material whose response to a deforming load combines both viscous and elastic qualities. The common name for such a material is "plastic".

W

Water activity	The ratio of the vapour pressure of water in a material to the vapour pressure of pure water at the same temperature.
WHO	World Health Organisation.
Widget	A small device in a beer can which, when the can is opened, releases nitrogen gas into the beer, giving it a head. See Smart Packaging www.idtechex.com
WiFi	Popular name for the IEEE 802.11 family of wireless standards, embraced by the computer community to connect laptops wirelessly to broadband networks in airports, homes, coffee shops, bars and parks. It predates Bluetooth. WiFi has been installed in many laptops and handheld devices but it has yet to be widely used in mobile telephones, partly because it is more power hungry than Bluetooth. It is faster and gives devices longer range. The main frequency used is 2.45GHz. There is some interest in combining WiFi and RFID functionality for certain applications.
WiFi Alliance	A non profit international association that certifies products to ensure interoperability based on IEEE 802.11
Write	The transfer of data to a tag and the tag's internal operation in storing the data. It may include reading the data in order to verify the operation.

Write rate The rate at which the information is transferred to the tag, written into the tag's memory and verified as correct. It is measured as the average number of bits or bytes per second in which the complete transaction can be performed.

Z

Zeolite A class of hydrated aluminium silicates of calcium, sodium, or potassium used in ion exchange and as selective absorbents.

ZigBee Alliance A group of about 50 companies developing the IEEE 802.15.4 standard. This is for a relatively low speed, low power consumption wireless network technology. The Alliance targets devices that need long battery lives – months to years – such as remote controls and sensors. It is likely to complement Bluetooth rather than compete with it.

Appendix 2

EPCglobal and The Internet of Things

Appendix 2: EPCglobal and The Internet of Things

The concept of The Internet of Things is to have things "talking" at very low cost to things over the Internet, mainly by means of RFID tags of unprecedentedly low cost so they can be fitted economically on almost anything. There will be little or no human involvement and resultant error. That means that most of the tags will be "read-only" and have no more than one meter range and no more than 128 bits of information on them. Indeed, the information will usually be confined to a unique product code. Target price is 1 cent per tag when they are on everything in the supermarket for example. The project and the standards process involving ISO is being managed by EPCglobal which is owned by UCC and EAN, the standards bodies behind barcodes

EPC

Similar to UPC/EAN bar codes, the Electronic Product Code (EPC) used in RFID tags is divided into numbers that uniquely identify the manufacturer and product. However, according to Sue Hutchinson, products manager at EPCglobal US (a joint venture formed between the UCC and EAN), the EPC extends the versatility of the traditional coding structures significantly by incorporating an additional field for serialization to encode information such as lot/date data.

"Our initial focus is on RFID as the carrier, but the EPC is designed to be used with other data carriers such as RSS [Reduced Space Symbology] or 2D codes," Ms. Hutchinson explained. "We foresee applications where cases and pallets will be RFID tagged and the same code structure used with other data carriers (such as RSS) for shelf-ready products, to accommodate various network system components."

The EPC is comprised of four variable-length fields: The first is a header that provides reader decoding instructions, such as field lengths and code type (UCC/EAN, GTIN, etc.). The second field contains whatever manufacturer IDs companies may be using in order to facilitate speedy adoption and leverage existing IT investments. The third field encodes the object class item reference, which may be the UCC/EAN item number and/or the manufacturer's SKU; and the fourth field, serialization info. RFID's data-intense, small form factor makes this degree of ID flexibility possible.

"The EPC allows more information capture than established bar code technology," Ms. Hutchinson said. "It's going to be very exciting over the next few years to see how information systems and processes will change to take advantage of this data. I think the supply chain will open up in terms of total asset visibility, where at any given moment we'll know where goods are in transit and how long they've been there. Transportation and logistics operations are going to change, we think in fairly short order."

Several pilots are currently underway in the CPG arena, among them a Tesco warehouse in the UK, but the EPC technology has multi-industry and sector applicability, according to Ms. Hutchinson. "The EPC network is here now. Now is the time to gather information and form exploratory groups. The Wal-Mart mandate is certainly the key driver in CPG," she noted, "and there's a very decided first-mover competitive advantage for other industries, too."

EPCglobal US's Web site is a prime resource for information on education, training, certification, and compliant technology vendors. Currently, Matrics and Alien Technology supply EPC-compliant tags for Class 0 and Class 1 Air Interface protocols, but more are in the wings. EPC standard specs are available at www.autoidcenter.org.

Confusingly, the term EPC is also now used to describe the whole open system and enabling software that can be licensed from EPCglobal

Auto ID Centers

From 1999 onwards, Auto ID Centers were set up across the world eventually backed by over 100 sponsors including IDTechEx to create enabling software, a new numbering system to handle the very large number of unique identities and other catalysts to make it happen. The Consumer Packaged Goods (CPG) industry was in the driving seat but military, postal and other potential users backed it almost from the start as well as standards bodies. Headquarters was at Massachusetts Institute of Technology until the whole process was handed over to the newly created EPCglobal in 2003.

The race for The Internet of Things smart label

It is not yet certain whether chip or chipless tags are best for highest volume and even the nearest-to-ideal frequency is debatable. Standards are being written for several classes, based on designs employing silicon chips, with the exception of read only Surface Acoustic Wave tags which will have a sub category. The classes include

- Class 0 Factory programmed read only
- Class 1 user programmed Write Once Read Many Times WORM
- Class 2 Read write

Force feeding UHF

Quite rightly, given the progress towards UHF becoming available as an RFID band worldwide (though at different power levels and different precise frequencies) Wal-Mart, the US Military,

Tesco, largest UK retailer, and other opinion formers have chosen it for case and pallet level tagging. That is because a range of several meters is needed with good multi-tag reading. Tag size does not matter in these applications (UHF tags tend to be relatively large) and problems with intervening water and metal are manageable.

Logically, these companies will try to extend their "one product fits all" philosophy to item level tagging, ignoring the fact that there are already 100 million items with tags on individual items in libraries and laundries and these work at either 125-135KHz or13.56MHz. These companies and their allies want to tag trillions of packages in supermarkets and elsewhere every year and that calls for something extremely cheap and small and tolerant of metal and water – all bad news at UHF. The jury is therefore out on whether UHF systems can be made to work well enough for this, though it is absolutely right that the main backers of the Internet of Things should use UHF for as much as possible to minimise system cost and complexity.

Chipless tags a possibility

Some chipless tags could eventually meet the highest demand that the Internet of Things requires in many circumstances, but most technologies still lack the necessary data, are mostly single-sourced, and have less investment than the chip projects (though chipless laminar transistor circuits are receiving rapidly growing investment now). Chip smart labels have huge amounts of investment, and hundreds of companies throughout their value chain. There are chipless tags available at UHF and 2.45 GHz and most other frequencies used for chip RFID. One – the Surface Acoustic Wave (SAW) type, is being trialled by the MIT Auto ID Center for item level use in high volume.

Whenever silicon foundries are busy, priority is given to higher-margin, higher-price chips. Chip capacity may never be made available for the trillions needed in the biggest potential applications such as archiving, replacing supermarket barcodes or providing proof of ownership. However, chip tags hold the stage for now.

EPC, ONS, PML & SAVANT

The MIT Auto-ID Center has developed four key elements to help realize The Internet of Things in its ultimate form of uniquely identifying thousands of trillions of items in an open system modelled on barcode numbering. These are:

- The Electronic Product Code (ePC now also written as EPC), which is intended to uniquely identify physical objects.
- The Object Naming Service (ONS), which acts as the 'glue', linking the ePC with its associated data file.
- The Physical Mark-up Language (PML), which is intended to be the standard in which networked information about physical objects is written.
- Savant, which is distributed application software.

We now look at these systems, and their options, in more detail. They are backed by what is now a chain of Auto-ID Centers across the world, headquartered at MIT. The sponsors are end users and they manufacture about one trillion products with barcodes every year.

The Electronic Product Code (ePC or EPC)

The Auto-ID Center at MIT describes its system as:

"A numbering scheme that can provide unique identification for physical objects, assemblies and systems. Information is not stored directly within the code - rather, the code serves as a reference for networked (or Internet-based) information, in other words, the code is an "address" - it tells the computer where it should go to find information on the Internet.

The ePC requires relatively few parameters to determine the design:

- Number of bits - i.e. How much information is needed to provide a unique identity in every single product manufactured, sold and consumed in the global supply chain?
- Bit "partitions" - i.e. What is the best way to organize - or "break up" – the numbers/figures so that we achieve as many unique combinations as possible, while also expediting Internet searches?

Consider this an exercise in determining the best "search hierarchy" - like a postal address - which goes from country to city, to zip code, to street, to house and individual. As the detail or level of the hierarchy increase, the speed and accuracy of the search will likewise increase, but the possible combinations of unique numbers will decrease".

To be precise, MIT Auto-ID Center call for 96 bits in the smart label for The Internet of Things and, in some presentations, far more. The data are to be employed in four zones mimicking barcode numbering systems but running to far more numbers because barcodes rarely identify anything uniquely and the Auto- ID Centers headquartered at MIT intend to facilitate tagging of even greater numbers of items than barcodes today.

The Auto-ID Center were willing to start with tags having only 64 bits. However, more recently Wal-Mart, Target, Tesco, Carrefour, Metro and the US Military have mandated 96 bits usable by the retailer meaning 128 bits overall. However, big systems houses backing EPCglobal have also advocated that they are develop an EPC based on 256 bits. Even though 96 bits is more than enough for more than thousands of trillions of unique identities, the numbers distributed will be in batches, i.e. items are not numbered from 1 upwards, so there is a fear of a "year 2000" type of problem in something over one hundred years particularly if tags often store more than ID. Indeed, the debate about data content and structure is reminiscent of early barcode implementation. Both pharmaceutical and defence, while endorsing EPC, have identified coding needs that exceed the capacity of current Class 1 Generation 1 EPC tags – and may not even be addressed by proposed 96 or 128 bit capacity Gen2 tags.

EPCglobal has stated that it intends its RFID standard within ISO will be inclusive of other coding conventions. However, some worry that EPCglobal appears ready to abandon the GTIN, which is the very foundation of the EAN.UCC coding structure and the heart of countless product databases.

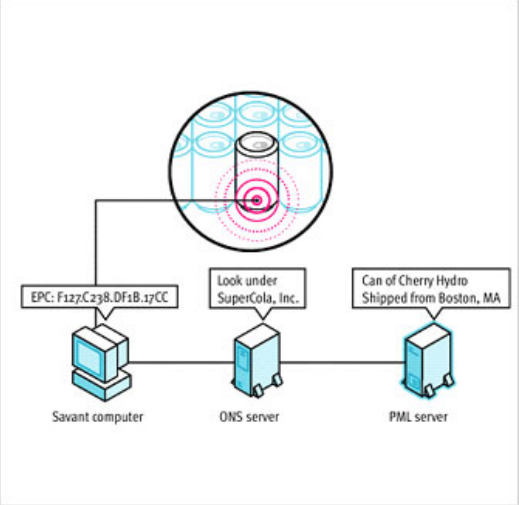
Other troubling news is that the Chinese government is developing its own version of EPC – although whether this would be technology-based or coding structure or both is not yet clear.

X	XX	XX	XXXXX
HEADER	MANUFACTURER	PRODUCT	SERIAL NUMBER
8 bits	28 bits	24 bits	36 bits
	268 million+ Unique IDs	16 million+ Unique IDs	68 billion+ Unique IDs

Source: Auto-ID Center

Object Naming Service

Fig A2.1 The MIT Object Naming Service (ONS) 'tells computer systems where to locate information on the Internet about any object that carries an EPC (Electronic Product Code).



Source: Xplain

ONS was developed at the Massachusetts Institute of Technology by Dr David Brock, Professor Sanjay Sarma and Joseph Foley. ONS is similar to - and (in part) based on - the Internet's existing DNS (Domain Name System), which allows Internet routing computers to identify where the pages associated with a particular Web site are stored.

The DNS is used every time a Web site is accessed. The ONS will be used every time information is needed about a physical object. It is likely that the ONS will be many times larger than today's DNS.

Although conceptually simple, designing ONS was a challenge. The system must be capable of quickly locating data for every single one of the trillions of objects that could potentially carry an EPC code in the future. The ONS must serve as a lightning-fast post office that, on a daily basis, receives and delivers millions (if not billions) of letters.'

Product Mark-up Language

Product mark-up language, or PML, is billed to be a standard "language" for describing physical objects. It will be based on the extensible Mark-up Language (XML).

Today, HTML (Hyper Text Mark-up Language) is the common language on which most websites are based, allowing individuals to surf the Internet from their desktops regardless of the type of computer or operating system used. Where HTML tells a computer how information should be displayed (e.g. what colour and size it should be) - XML goes a step further, telling the computer what kind of information it is viewing (e.g. an address or a telephone number). The PML will go even further, building in layers of increasingly specific data in order to describe physical objects, their configuration and state. In the end, PML:

Should translate or contain static data such as dosage, shipping, expiration, advertising and recycling information.

Should provide instructions for machines that "process" or alter a product, such as: microwaves, laundry appliances, machine tools and industrial equipment. May need to communicate dynamic data: information that changes as a product ages or as it is consumed, such as: volume, temperature, moisture and pressure.

May need to include software, or programs, which describe how an object behaves, for instance: a PML file may contain the program which describes how fast the tyres on your car will wear before they need to be replaced, or how fast an object may burn in case of a fire.

Savant™

In a world where every object has an RFID tag, interrogators will report a continual stream of EPC™ codes. Managing and moving data is a difficult problem and one that must be overcome if a global RFID network is to be of value. The Auto-ID Center has made software technology called Savant™ to act as the nervous system.

Distributed architecture

The Savant™ system is different from most enterprise software. It is not one overarching application. Instead, it uses a distributed architecture and is organised in a hierarchy that manages the data. There will be Savant™ software running in stores, distribution centers, regional offices, factories, perhaps even on trucks cargo planes, according to the Auto-ID Centers. Savants at each level will gather, store and process information and interact with other Savants. For instance, a system at a store might inform a distribution center that more product is needed. The Savant system at the distribution center will inform the store Savant that a shipment was despatched on time. Some of the tasks the Savants will handle are given below:

Data smoothing – The Savant™ software at the edge of the network – the interrogators – will smooth data. Not every tag is read every time. Sometimes a tag is read incorrectly. By using algorithms the system is able to correct these errors.

Reader co-ordination – If the signals from two readers overlap, they may read the same tag producing duplicate EPCs. One of the Savant System's tasks is to analyse reads and delete duplicate codes.

Data forwarding – At each level, the Savant has to decide what information must be forwarded up and down the chain. For instance, Savant™ Software in a cold storage facility might forward only changes in the temperature of stored items.

Data storage – Existing databases cannot handle the data of an Internet of Things fast enough, so another job of the Savant™ system is to maintain a time in memory event database. In essence, the system takes the EPC data that is generated in real-time and stores it intelligently, so that other enterprise applications have access to information, but databases are not overloaded.

Task management – All Savants, regardless of their level in the hierarchy, feature a Time Management System (TMS), which enables them to perform management and data monitoring using customisable tasks, for example, Savant™ Software running in a store might be programmed to alert the stockroom manager when product on the shelves is below a certain level.

Root Directory for EPCglobal Network

EPCglobal, an international standards organisation, has taken a significant step forward in the commercialization of RFID and electronic product code (EPC) technology by selecting VeriSign to provide the Object Naming Service (ONS) root directory for the EPCglobal Network, it was announced on 13 January 2004.

"To more effectively track pallets and cases of products throughout the supply chain, the EPC tag, when linked to the ONS, creates a unique identifier for each container," said Margaret Fitzgerald, President of EPCglobal. "When looking for a partner to build this root directory, it was clear VeriSign, based on its background as the domain name registry for the millions of Internet addresses in use around the globe, was the perfect partner for the job."

Linking a pallet or case of products through a unique number on the EPC tag is essential in ensuring true visibility of information about items in the supply chain, creating efficiencies and cost-savings for manufacturers, wholesalers, and retailers alike.

ONS is a major component of the EPCglobal Network. Coupled with the other components under development, the EPCglobal Network will serve as an open, global system that will allow trading partners to markedly improve their ability to track and share supply chain information. Benefits of the EPCglobal Network will include its ability to:

- Enable real-time, automatic location of cases and pallets in the supply chain
- Increase responsiveness to customer needs
- Provide increased visibility at all points in the supply chain
- Facilitate an open, collaborative environment with trading partners

Current EPC technology is limited to use at the case and pallet level.

"We are extremely pleased to have been selected to play a critical role in the EPCglobal Network, which is poised to be the enabling infrastructure of the next generation of supply chain management solutions," said Stratton Sclavos, CEO of VeriSign. "Our ATLAS platform is a proven infrastructure for highly scalable directory services, and provides the ideal solution for the volume of information requests the EPCglobal Network will support as the use of EPC technologies grows."

"With the EPCglobal Network, all supply chain members can take advantage of one of the most highly anticipated technological revolutions for business in a generation," Fitzgerald added. "EPCglobal's selection of VeriSign to design and operate the authoritative root for the EPCglobal Network was a natural choice."

EPCglobal, a joint venture between EAN International and the Uniform Code Council, Inc., brings a wealth of knowledge to the supply chain management environment. Over the last several decades the EAN.UCC System orchestrated the successful implementation of "bar code" technology. Bar codes were, until today, the de facto supply chain management solution. The alliance between EPCglobal and VeriSign, the leading provider of critical infrastructure services for the Internet and telecommunications networks, is the continuation of a revolution in supply chain management. The alliance is a combination of decades of proven expertise and experience in supply chain management and managing the complex systems of the .com and .net Domain Name System (DNS)..

Appendix 3

Achieving efficient global logistics execution

Appendix 3: Achieving efficient global logistics execution

Achieving Efficient Global Logistics Execution

How the convergence of real-time data collection technologies, wireless networks, and Web-based applications are creating new opportunities for supply chain efficiencies.

This document is intended for informational purposes only. It is not a commitment to deliver and may not be incorporated into any contract.

INTRODUCTION

This white paper sets forth Savi Technology's vision for more efficient and profitable commerce through real-time visibility of conveyances, goods, and shipments across the entire supply chain. It is written to inform logistics professionals about new automation technologies that will make it faster and easier to control the transportation of goods and improve communication between suppliers and customers. This document discusses the financial impact of current systems and the tremendous cost savings opportunities that are now possible because of these advances in technology.

This white paper concludes with an overview of Savi's solution. You will learn about:

- The extent of Savi's real-time visibility network.
- The SmartChain software platform that enables real-time visibility and collaboration.
- New Web-based solutions that provide information and functionality for shippers, conveyance leasing companies, 3PLs, and carriers.

CHALLENGES IN CURRENT LOGISTICS STRATEGIES

Getting timely and accurate information about the status of goods in the supply chain may seem like a simple request in our age of high-tech communications. In reality, it is extremely ambitious. Tracing the development and shipment of goods around the globe is tedious and complex, involving a large number of isolated— and often antiquated—systems. Trading partners and service providers still convey critical information through paper forms, faxes, and telephone calls, introducing the inevitability of human error. Even when goods are transported on time and in perfect condition, the shipper is never confident that that is the case until days later, simply because accurate information is not available quickly enough. Most information received today is “after the fact” when it’s already too late. Even EDI feeds require manual input at the source, which can result in inaccurate information that’s received out-of-sequence.

According to Forrester Research, a single global shipment of toys requires 27 parties to complete. Forrester also found that 76% of logistics managers at major companies could not trace products en route or get updates.

Then there's the issue of what to do when things go wrong, which they often do. Supply chains are subject to the fickleness of world markets and mundane environmental influences, such as storms, traffic, labor disputes, and even political strife. Journalists regularly uncover stories of multinational corporations that fail to meet demand or recover financially from accidentally destroyed goods. With accurate, reliable information at the right time, however, companies can significantly reduce errors, minimize incidental costs related to delays or disasters, optimize inventories, and stick to promised delivery dates.

SAVI'S VISION FOR EFFICIENT GLOBAL LOGISTICS EXECUTION

The goal of any logistics operation is to satisfy downstream customer demand while minimizing costs from upstream providers. More often than not, companies approach this challenge from a tactical perspective, grasping opportunities where they can be found throughout the supply chain, but rarely building efficiencies into the supply chain as a whole. This causes a situation known to IT professionals as “stovepiping.” Stovepiping is bad because isolated systems generally only offer one-time improvements. Integrated systems, however, can offer increasing value over time.

Savi offers a new and better way to manage the entire supply chain, not just isolated “links.” Savi understands that companies must optimize their entire supply chains in order to increase profitability, and they must react quickly to changing events in order to stay competitive. To provide the ideal solution, Savi’s strategy is to deploy a solid real-time network first, and then design and build applications on top of the infrastructure to service different supply chain members. As more members connect and operate with each other through Savi, they all benefit from increased efficiency at less cost.

Savi's vision for the efficient execution of global supply chains appears below.

Strategy	Implementation	Business impact
Automatically collect supply chain data	• Attach automatic identification tags to supplies, goods, conveyances, transport vehicles, and any other item that needs to be tracked. These can include RF (radio frequency) ID tags, GPS, and simple bar codes. • Optional: list the contents, status, condition, and dollar value of goods within each conveyance.	• Increases supply chain velocity. • Reduces stock handling. • Reduces labor costs. • Minimizes errors. • Ensures timely data collection. • Enables other real-time processes.
Transfer data in real-time to a shared, central location	• Install data collection devices at key transfer points to capture data as tagged assets move through the supply chain. • Data can also be entered through EDI transfers, XML, and manual data entry.	• Increases supply chain velocity. • Increases confidence in data accuracy. • Ensures data availability.
Make a single data repository available across the entire supply chain	• Develop a common data model (database) that enables all supply chain partners with seamless integration and communication. • Implement security standards to ensure that only authorized parties view sensitive information.	• Reduce data duplication. • Allows incremental improvements across entire supply chain; avoids "stove-piping". • Enables collaboration, better communication, and end-to-end visibility. • Simplifies logistics execution. • Improves measurement capabilities and trend analysis.
Instantly notify stakeholders of problems	• Program alerts to check for exceptions such as late arrivals. • Send notification via email, pager, fax, or Web.	• Enables early response to changing conditions. • Increases the likelihood of on-time delivery. • Increases accountability. • Provides an early opportunity to reset customer expectations when necessary, decreasing downstream impact.
Provide real-time visibility into supply chain status	• Create applications to track conveyances, shipments, inventory, and orders • Communicate status and work orders through the Web and handheld wireless device	• Enables more intelligent planning and faster response to changing conditions. • Enables cost-effective customization. • Reduces reporting times from days to minutes. • Reduces response times from days or weeks to minutes.
Replace error-prone and labor-intensive processes (paperwork, phone calls) with automated applications	• Develop Web-based logistics planning and routing applications that understand business process workflows for yard operations, warehousing, shipping, airfreight, and trucking • Transmit work orders in real-time to wireless handheld devices	• Reduces paperwork. • Eliminates human error. • Reduces labor expenses. • Accelerates logistics execution.
Integrate with other systems and offer customization features	• Integrate data feeds from EDI and manual data entry • Use XML to integrate with billing systems, ERP, advanced planning and forecasting, and other enterprise systems • Allow companies to configure and extend the applications and data model to meet their unique requirements	Enhances ROI of existing systems. • Expedites enterprise processes like ordering, billing, CRM, planning, etc. • Enables accurate business analysis and measurement. • Encourages companies to consider innovative new applications not previously possible.

SAVI: FULFILLING DEMAND FOR THE IDEAL SUPPLY CHAIN SOLUTION

Savi's vision for efficient execution of the global supply chain is fast becoming reality.

End-to-End Visibility Infrastructure

Savi leveraged over a decade of experience designing, deploying, and maintaining real-time data collection solutions to create a highly sophisticated real-time visibility network. The visibility infrastructure intelligently integrates data collection devices, an open communication protocol, and a scalable software platform for aggregating and sharing information in real-time.

Real-time Data Collection Devices

With over 300 network nodes in 21 countries, Savi Technology has the largest real-time global network. Savi is further extending this infrastructure to support wider real-time visibility into the location and status of goods moving around the world. In the field, automatic data collection and tracking technologies such as bar codes, wireless RFID (radio frequency identification) tags, and wide-area location technologies, such as GPS (global positioning systems) and cellular solutions, identify assets as they move from supplier to end customer. The infrastructure to collect asset information includes RF tag readers, bar code scanners, and other wireless devices. Local Savi Site Servers monitor and manage the data collection devices at customer sites and deliver data to the central SmartChain server.

Universal Data Appliance Protocol

UDAP, Savi's universal data appliance protocol, provides a common interface between data collection devices, such as an RFID readers, bar code scanners, weight scales, and gate arms, the SmartChain platform, and third-party enterprise software. Any UDAP-enabled device is immediately able to integrate with the real-time visibility SmartChain platform.

The innovative and powerful UDAP protocol offers many advantages, including:

- Extensibility and forward compatibility for new devices and technologies.
- Automatic self-discovery and registration of network devices, also known as "plug and play" capabilities.
- Minimal site installation effort.
- Remote network management and maximum network reliability.
- The opportunity to drive industry-wide standardization.

Savi SmartChain

The Savi SmartChain platform is the foundation for all Savi solutions, enabling end-to-end visibility across the entire supply chain. Whether leveraging existing EDI feeds and legacy interfaces, or tracking in real-time via RFID and GPS, the Savi SmartChain platform aggregates and translates data into meaningful information about the true location and status of conveyances, inventory, shipments, and customer orders. With robust event management functionality, the platform can identify problems and generate alerts to changing conditions within the supply chain as they happen. In addition to notifying the right people, alerts can trigger the right workflow to proactively address each event immediately. Savi SmartChain includes:

- Common data model and SmartChain Event Engine.
- Alert manager.
- Interfaces to legacy systems.
- Supply Chain Partner Manager, Workflow Manager, and Process Flow Manager.

Real-Time Solutions

Although RFID tags and readers have been around for over a decade, their true value is just starting to be realized. Software applications like Savi's are compelling enough to attach an RFID tag or other automated identifier to every major conveyance. The price/performance equation has evolved so that real-time and accurate information can now be easily collected anywhere in the world and immediately shared securely over the Web with a trade group. True real-time visibility increases efficiencies and profits across the entire supply chain.

Savi's suite of Web-based solutions for multi-national shippers, conveyance owners and leasers, and 3PLs (third party logistics providers) provides timely and meaningful information about the location and status of conveyances, goods, and shipments. As an extension of the Savi SmartChain platform, these new business intelligence applications make sense of the vast amount of data that is collected every day by providing the appropriate context, filters, and links to relevant information. The Savi SmartChain platform provides unprecedented visibility by ensuring that the data is reliable, real-time, and error-free.

Savi real-time solutions come pre-integrated with the Savi SmartChain platform and all other Savi SmartChain Solutions to provide true end-to-end visibility. Real-time alerts and notification messages are configurable to reflect any type of supply chain event, such as an advance shipment notice (ASN), advance arrival notice (AAN), late arrival, excessive dwell time, inventory high/low, misrouting, and shipment loss.

Savi provides real-time solutions for:

- Conveyance management.
- Asset management.
- Performance management.
- Global inventory management.
- Shipment management.

Savi Conveyance Management

Savi Conveyance Management is designed to help conveyance leasing companies, 3PLs, and industries that typically own reusable transport containers—such as air cargo, chemical, auto, and grocery—drastically reduce conveyance carrying costs and increase quality and customer service. Operations employees, equipment managers, and production floor supervisors use a simple Web browser to plan conveyance usage, access real-time location and status information, and make on-the-fly changes as supply and demand change.

Challenges in Conveyance Management: Conveyances such as pallets, totes, racks, Unit Loading Devices (ULDs), and other reusable containers are necessary to transport goods throughout the supply chain. If conveyances are not managed well, supply chain operations halt when there are not enough on hand to move goods forward to the next transporter. This may happen when too many conveyances accumulate at one location; become damaged, aged, are stolen or lost; or are in high demand. Under these circumstances, logistics managers cannot profitably meet demand throughout the entire supply chain. Without better visibility into the location and status of conveyances, the only recourse is to purchase excess conveyances—some of which cost thousands of dollars—to satisfy peak demand at all choke points.

A major auto manufacturer conveys chassis from a supplier to their plants using expensive engine cradle racks. The company is constantly running out of racks and they have no idea where they are. The company also suspects that the rail company that transports the racks is running inefficiently, but they have no evidence to confirm this.

In addition, since 3PLs and conveyance leasing companies have little insight into the duration and total number of turns per conveyance, they can't optimize their billing based on actual usage and customers are not motivated to use conveyances efficiently.

Solution: Attach automated identification devices, such as RFID tags, to conveyances and use Savi SmartChain to capture real-time location information as they move through the system. Conveyance managers access the Savi Conveyance Management Web application to plan when and where conveyances should be used and redirect unused conveyances to high-demand locations. Savi Conveyance Management also provides real-time notification when inventory is low or when conveyances fail to show up at their destination.

Analysis reports root out causes of breakage, loss, and theft. Built-in alerts and reports can also ensure that aging conveyances are removed from service before they break, and those that require inspection, cleaning or other certifications between uses are handled appropriately. Conveyance owners can also integrate Savi Conveyance Management with their ERP systems to initiate immediate billing that is tied directly to customer turns.

Business Impacts: Accurate and detailed visibility into conveyance status and location allows logistics managers to schedule shipments more efficiently and profitably.

Real-time end-to-end visibility, built-in alerts, and sophisticated analysis tools allow conveyances to be used more often, thereby:

- ☑ Reducing capital expenditures on new assets.
- ☑ Ensuring that conveyances are always available to keep the supply chain in motion.
- ☑ Anticipating and managing demand fluctuations.
- ☑ Recovering expenses due to breakage, loss, age, and misuse.
- ☑ Reducing transportation costs.
- ☑ Reducing exposure to legal claims through mishandling.
- ☑ Increasing the return on investment in conveyances.
- ☑ Improving the billing process.

Savi Asset Management

Savi Asset Management gives businesses insight into the exact location and status of their valuable assets. Regardless of your business, Savi Asset Management will enable your organization to effectively manage, control and track your specific organization's assets in real-time via a web-based interface.

Challenges in Asset Management: Companies owning millions of assets across all industries face the challenge of locating their valuable assets. Whether it's expensive hospital equipment or heavy manufacturing tools, the assets that are key to a company's success are frequently lost, stolen and almost always underutilized. Lost business-critical assets often create excessive work stoppage costs.

Many companies rely on tracking their assets manually with paper forms and human resources. These manual processes lead to excessive paperwork, inevitable errors and ultimately numerous lost assets. The result is additional costs for more resources to control asset tracking and more revenue spent on replacing lost assets.

Solution: Track and monitor the valuable items in your enterprise using in-expensive tags and Savi's Real-Time locating technology. When an item, such as a hostler in a yard or a generator out in the field is missing, companies can easily log onto Savi's Asset Management web-based interface, type in the asset identification number and quickly locate the missing item. All data is collected and managed in real-time within a completely collaborative model, so asset information is available from any web-browser at anytime.

Business Impact: If a business cannot quickly and easily account for all their assets, time and money is wasted trying to locate and control them. This wasted time and money could be spent evaluating future opportunities and proactively responding to changes in the business world. With real-time tracking of all assets, companies are able to:

- ☑ Increase asset utilization.
- ☑ Reduce capital expenditures on new assets.
- ☑ Quickly locate valuable equipment before aging costs escalate.
- ☑ Recover expenses due to breakage, loss, age and misuse.
- ☑ Enhance customer service and responsiveness.
- ☑ Reduce labor to locate assets.
- ☑ Eliminate labor-intensive data collection and item searches.
- ☑ Reduce manual tracking errors.
- ☑ Reduce work stoppages and slowdowns due to missing assets.
- ☑ Provide better product quality.
- ☑ Extend asset life.
- ☑ Track the history of an asset and analyze individual ROI.

A major toy retailer was not able to control its extensive worldwide inventory in the late 1990's. Years of inventory gluts were followed by a dismal 1999 holiday season that left U.S. stores out of stock on 36% of items. In addition to millions of dollars in lost revenue opportunities, the Federal Trade Commission fined the retailer $350,000 for its inability to inform online customers when items were out of stock.

Savi Performance Management

Savi Performance Management gives Multi-National Shippers and Lead Logistics Providers the ability to measure the performance of their supply chain. By tracking a set of a company's assets, businesses can measure the weak links in the supply chain and review key performance indicators to improve supply chain velocity.

*Challenges in Performance Management: S*upply chains do not execute at the most efficient level possible. Routing problems and bottlenecks cause shipment delays and erroneous deliveries. Many shipments are damaged or lost in the distribution process. Days are added to the supply chain as a result of extended dwell times, lengthy transportation time and extensive custom clearances. Due to these inefficiencies, companies must keep more inventories on hand and must endure unnecessary operational costs such as demurrage fees and expediting costs. Live statistical data about the supply chain will allow you to identify and correct inefficiencies.

Each link in the supply chain needs to be analyzed for optimum performance. For example, if each link in the supply chain is operating at a 95% on time delivery rate it may appear that the supply chain is fairly efficient. However, if each of five links is operating at 95%, then the overall predictability of on time delivery is only 77%. Using Savi Performance Management each link in the supply chain is analyzed for optimal performance allowing you to vastly improve the predictability and reliability of shipments.

Solution: Data tags are placed on a select number of shipments. As shipments travel through the supply chain, the items tagged will be read at key ports, yards and other choke points. The Savi SmartChain Platform gathers this data, aggregates it with data from other sources such as EDI and transactional data and converts it into meaningful information. Using the web-based Savi Performance Management Solution, companies can measure the reliability of logistics providers by reviewing data such as estimated time of arrival, estimated storage target date and estimated time of shipping. Based on a set of all shipments, businesses can accurately estimate demand and volumes with key performance indicators.

Business Impact: Basically, you can't fix what you don't measure. By analyzing the statistical data from a sample set of supply chain activities, businesses discover exactly where the inefficiencies exist. Applying the knowledge from this valuable analysis companies will be able to:

- ☑ Improve supply chain velocity.
- ☑ Reduce operational costs.
- ☑ Identify consolidation potentials.
- ☑ Improve customer satisfaction.
- ☑ Continually improve the supply chain process.
- ☑ Reduce inventory levels.
- ☑ Guarantee just in time delivery.
- ☑ Reduce detention and demurrage fees.

- ☑ Identify and address supply chain inefficiencies.
- ☑ Reduce days in the supply chain.

Savi Inventory Management

Savi Inventory Management gives shippers and other supply chain partners the ability to see inventory across the entire supply chain. Savi Inventory Management is a Web application that allows purchasing, inventory management, distribution operations, and other inventory related functions to view inventory levels, consolidate or split orders from multiple warehouses, and make economical, on-the-fly fulfilment changes from stock that is in a warehouse or in-transit. Savi Inventory Management provides the tools necessary to put the supply chain to use as a virtual warehouse.

Challenges in Inventory Management: Inventory management is one of the most challenging and expensive aspects of supply chain management. Companies are constantly balancing inventory carrying costs and obsolescence with customer fulfilment requirements. Retaining too much stock incurs unnecessary warehousing costs, ties up valuable capital, and can expose vendors to significant financial losses if demand drops. With little or no insight into available upstream inventory, downstream manufacturers, distributors, and retailers cannot commit to large or rush orders with any confidence and may not even be able to deliver on forecast. The lost opportunity and overage costs can be significant for all members in the supply chain.

Solution: Using data retrieved from real-time wireless devices, EDI transmissions, and/or manual entry, Savi Inventory Management provides up-to-date information on how much inventory is available throughout the entire supply chain, whether it's in storage or in transit, and whether it is already committed to an order. Savi Inventory Management enables total visibility for inventory across modes and trading partners. It can also track the estimated time of arrival for in-transit inventory and hence improve the available to promise performance without increasing the inventory levels. Savi Inventory Management tracks key performance indicators and provides tools to analyze product loss, demand variability, success of just-in-time delivery, and vendor-managed inventory processes.

Business Impacts: Despite its challenges, inventory management offers one of the largest opportunities in supply chain management. End-to-end inventory visibility increases buyer purchasing power, minimizes inventory levels, ensures product balance, and ultimately reduces warehousing costs.

With real-time visibility to the entire inventory, companies are able to:

- ☑ Commit to orders and delivery dates with confidence.
- ☑ Reduce safety stocks.
- ☑ Avoid "channel stuffing".
- ☑ Identify sources for emergency or rush orders.
- ☑ Reduce shipping costs by scheduling shipments from the nearest fulfilment center.
- ☑ Direct fulfilment from multiple warehouses at once, thus optimizing the use of each warehouse.
- ☑ Redirect long-lead orders to fulfil rush orders while still meeting expectations for the original order.
- ☑ Reduce rush-order transportation costs.
- ☑ Improve capital utilization.
- ☑ Enhance customer service and responsiveness.

Savi Shipment Management

Savi Shipment Management is designed to provide visibility into multi-modal shipments. Shippers, logistics providers, and freight forwarders can all use Savi Shipment Management to gather detailed information on their shipments.

Union Pacific's merger with Southern Pacific Railroad in 1996 created problems that resulted in tremendous logjams. Shipments for the 1997 Christmas holiday season were lost for weeks at Los Angeles ports and the Houston rail yard.

Challenges in Shipment Management: When available, most shipment management software only operates on a "pull" method, providing location and status information only when a shipper requests it. Without any method to "push" information intelligently, such as late arrival notifications, shippers are less likely to meet or reset customer expectations. Current software also does not view the entire supply chain as a whole, requiring users to use different systems when goods are transported from air to truck, for example, or leaving gaps where the only tracking method is to talk to someone during their normal working hours. This can be especially burdensome when shipments are being transported around the world.

In-transit information is inaccurate, late, or not provided at all. Multiple hand-off points across the supply chain make it difficult to track the location of a shipment, and there is usually no warning of missed or late shipments.

Solution: Use Savi SmartChain as the data collection platform to automatically gather real-time information as goods pass through ports, yards, and other choke points. Then use Savi Shipment Management to track shipments over the Web. Savi Shipment Management software tracks all information about the movement of a shipment, including what it contains, who is carrying it, a history of its progress through the supply chain, and scheduled delivery dates. When a shipment does not arrive on time, Savi Shipment Management sends an alert to the shipper or other authorized person, including an updated estimated time of arrival.

Everyone in a trade group can manage proof of delivery (POD) information using a secure Web-based Self Service Proof of Delivery feature. The POD can be viewed at the Bill of Lading level and automatically updated every time a vehicle has a planned drop off. In addition, shipments can be tied to a purchase order or other shipper's identification number, simplifying and speeding up the flow of information to the people who need it.

Business Impacts: Savi Shipment Management prevents errors and minimizes delays of precious cargo. Real-time shipment visibility:

- ☑ Provides better customer service.
- ☑ Helps shippers identify the best carrier for a job.
- ☑ Speeds up supply chain velocity.
- ☑ Reduces errors.

Real-Time Logistics Execution Solutions

Savi logistics execution Solutions include business process workflow rules that understand the complexities of supply chains and can specify how and when goods should flow from one node to the other. Automation ensures speed and accuracy, greatly reducing opportunities for errors or delays.

When something goes wrong, however, such as a late shipment, people who need to know about it receive an urgent email, page, or fax. A logistics professional can then assess the problem by logging onto a secure Web site to view the details about the late shipment, including an automatically generated estimated time of arrival. He then uses the same Web interface to retrieve up-to-date information on how much inventory is on hand, where it's located, and how much of it is committed to other orders. He can also use Savi logistics execution Solutions to handle any "paperwork" related to a shipment, including Bill of Lading, customs clearance, import/export declaration, letters of credit, insurance documentation, and proof of delivery. In a matter of minutes, he can make a highly informed decision on how to handle the situation and follow up with immediate action.

A fire at a Philips semiconductor plant in Albuquerque, NM on March 17, 2000 ruined the supply of radio frequency chips used in Nokia and Ericsson mobile phones. Nokia noticed an accounting disparity, discovered the problem, and deployed a 30-person team over a span of four weeks to find or create new parts and meet their production numbers. Ericsson did not gain visibility into the supply chain and reportedly lost at least $400 million in potential revenue.

Savi provides real-time logistics execution Solutions for:

- Yard management
- Warehouse management
- Airfreight
- Sea freight

Trucking

Savi Yard Management

Savi Yard Management helps 3PLs and shippers manage all aspects of yard operations. Yard supervisors, inbound and outbound logistics coordinators, and dispatch operators use the Web and wireless handheld devices to track receiving and shipping, allocate space, and manage truck movement throughout a yard.

Challenges in Yard Management: All too often, truck yard supervisors do not have the tools or information they need to manage the yard efficiently. Relying primarily on yard hostlers to fill out paperwork as trucks move into and within the yard, critical information is invariably lost and costly mistakes are made. Not knowing where trucks are located, what they contain, or when they should be unloaded makes it difficult to optimize slot usage, prioritize container unloading, and manage space during peak demand. Without knowing when a specific trailer can be unloaded or moved, demurrage charges accumulate and shipments fall behind schedule.

Solution: Savi Yard Management provides increased efficiency and visibility into yard operations. Through an intuitive visual representation of the physical yard, the yard manager can issue move orders by simply dragging a trailer icon to its intended destination. This "drag and drop" action automatically issues a text command to yard hostlers, speeding up operations and eliminating confusion. Savi Yard Management provides both text reports and a continuously updated visual map of the yard itself, color-coding trailers and containers as full, partially full, or empty for faster decision-making. Savi Yard Management automatically generates a history for audit purposes and tracks key performance indicators to provide yard managers with the information necessary to make informed decisions.

By adding RFID tags to yard equipment and conveyances and installing a reader infrastructure throughout the yard, Savi Yard Management automates check-in, location and status tracking, and activity reporting. When used with the SmartChain platform, Savi Yard Management can provide content visibility into the conveyances in a yard. By linking the Advance Ship Notice to the order and the conveyance ID, authorized

personnel can view the manifest over the Web. Real-time notification of shipment arrivals and excessive dwell times allows the yard to operate more efficiently and minimizes costs. Savi Yard Management even provides item level searching of the contents of conveyances in the yard without physically opening the trailers.

Business Impacts: Savi Yard Management can enhance customer satisfaction and increase profits by:

- ☑ Increasing yard throughput.
- ☑ Reducing operating costs.
- ☑ Minimizing product spoilage, demurrage costs, and unintentional moving costs due to lack of information.
- ☑ Prioritizing freight unloading meet highest demand.
- ☑ Eliminating labor-intensive data collection and item searches.
- ☑ Automatically generating an audit trail for conveyance received into the yard.

Savi Warehouse Management

Savi Warehouse Management manages receipts, shipments, space allocation, and the movement of goods within a warehouse.

Challenges in Warehouse Management: The purpose of warehousing inventory is to have items accessible within a reasonable timeframe for downstream manufacturers or customers. Yet most warehouses do not have an accurate inventory of what's in stock, cannot find what they're looking for efficiently, and have difficulty finding a suitable location for incoming shipments. In times of labor shortages, warehouses still rely heavily on people to optimize the allocation and movement of items. Relying on human ability can be especially daunting — if not impossible—in very large warehouses that can span several miles.

Solution: Savi Warehouse Management provides a better, more efficient way to manage the day-to-day operations of a warehouse. It automatically receives inbound load information and Advance Shipment Notices (ASNs), which helps with space allocation and staffing requirements before shipment arrival. Integration with the SmartChain platform ensures real-time, accurate receipts and enables cross-docking. Savi Warehouse Management uses a preferential rule-based algorithm to determine the best storage location for each item as it is received and automates stock put-away. Real-time scans throughout the warehouse validate proper storage and verifies inventory. Savi Warehouse Management also automates the picking process, creates all necessary documents, such as packing lists, manifests, and bills of lading, and uses RFID technology to quickly validate that outgoing product is on the right trailer.

Real-time reports provide unprecedented visibility into warehouse utilization, dwell time, loss, inventory, capacity, shipments, and receipts. Instant alerts also notify operators through the Web, email, pager, or fax of Advance Shipment Notice (ASN); Advance Arrival Notice (AAN); late arrival; excessive dwell time; inventory high/low; and shipment loss. Integration with third-party applications speeds up billing and more accurately reflects storage usage.

Business Impacts: Savi Warehouse Management provides unprecedented insight into the location and status of all warehoused inventory. It also replaces paperwork and manual processes with intelligent automation devices, greatly reducing errors and speeding up operations. Savi Warehouse Management can have a positive impact on the entire supply chain by:

- ☑ Reducing inventory handling.
- ☑ Reducing labor costs.
- ☑ Minimizing shipment errors and delays.
- ☑ Optimizing space utilization.
- ☑ Speeding up the billing process.
- ☑ Maximizing overall warehouse efficiency.

Savi Sea Freight

Savi Sea Freight simplifies the complex operational activities faced by the Non-Vessel Operating Common Carrier (NVOCC) operators and freight forwarders.

Challenges in Sea Freight Management: Sea freight management is a specialized profession that requires intimate knowledge of local and international regulations, port policies, and varying contracts between shipping companies and their customers. The work is complex, time-consuming, and relies heavily on the transfer of paper forms in order to keep containers flowing to and from ports. Paperwork inevitably becomes lost, which means containers also become lost. If forms are not filled out properly or on time, shipments are delayed, demurrage fees mount up, and expensive law suits result. Without a simple way to reduce errors and ensure accuracy and efficiency, sea freight management remains a frenetic and crisis-prone occupation.

Solution: Savi Sea Freight creates and prints import, export and transhipment quotations. The system automatically captures incoming shipment information and generates notes for billing and payment, as well as documents authorizing release and delivery. The electronic transfer of information and instructions also eliminates discrepancies arising from double data entry. Savi Sea Freight's export module monitors available carrier/container space as it manages export shipment bookings, transhipment processing and reservations. The system generates all required reports, including the Bill of Lading for export shipments, and automatically calculates volumetric/rate weight or quantity for the computation of charges.

Savi Sea Freight generates both standard reports as well as a variety of customizable reports such as cost analysis, top customers (by revenue or by tonnage), cargo agents' sales and discrepancy reports. To ensure security, users can be classified into different categories with varying access rights for each group. In this way, access can be controlled right down to the individual level. The system also maintains master records on the profiles and rates for customers, agents, shipping carriers and vendors.

Business Impacts: A highly scalable solution with a strategic focus on transhipment management, Savi Sea Freight:

- ☑ Reduces manual effort.
- ☑ Improves accuracy.
- ☑ Speeds up the quoting process.
- ☑ Smooth imports and export processes.
- ☑ Automates documentation needed to prevent unnecessary charges and ensure payment for reimbursable expenses.

Savi Airfreight

Savi Airfreight enables airfreight forwarders to track shipments globally and in real time to provide their customers with up to date information anytime, anywhere.

Challenges in Airfreight Management: Airfreight is the transportation option used when goods need to move quickly in the supply chain. As a premium service, it costs much more than sea, rail, or truck, and accordingly, customer expectations are much higher. Airfreight logistics share some of the same challenges as the other modes of transportation, though, which means that common mistakes and delays can be even more damaging throughout the entire supply chain.

Solution: Savi Airfreight manages complex shipment processes. Shipments are manifested for each route code and each mode of transportation. Real-time data feeds into the Savi SmartChain platform constantly update the status history for every shipment from the time it is booked, picked up, and manifested until proof of delivery. This real time information includes details such as status time and the person-in-charge at each stage of the shipment.

Orders for Y2K-compliant equipment caused a huge surge in air cargo shipments in 1999. Shippers resorted to chartering full freighters at 400% the cost because the scheduled airlines and freighter services were not able to meet demand. Real-time visibility and logistics execution Solutions could have saved millions of dollars.

Savi Airfreight also maintains master records on the profiles and rates for customers, agents, shipping carriers, and vendors, and provides user-configurable business intelligence on cost analysis, top customers (by revenue or by tonnage), and cargo agents' sales and discrepancy analysis. A sophisticated billing structure and a powerful reporting module complement the supply chain functions to provide a streamlined management system for the fast-paced airfreight industry.

Business Impacts: With a focus on timeliness and accuracy, Savi Airfreight:

- ☑ Reduces data entry errors and delays.
- ☑ Provides the flexibility needed to respond to customers' changing requirements.
- ☑ Streamlines the flow of cargo and information.
- ☑ Improves the billing process.

CONCLUSION

Savi believes that the combination of real-time data collection, wireless networks, and Web-based applications are creating incredible opportunities for supply chain efficiencies. Collaboration and real-time visibility throughout the entire supply chain will fundamentally transform how vendors and partners communicate and do business with each other, increasing accountability while at the same time reducing the risk of errors and exposure to legal claims. Everyone along the chain can plan better, respond to emergencies faster, and ultimately increase their operating margins.

This white paper mapped out Savi's plans for how it is making this vision a reality. Leveraging the real-time network that is already in place around the world, the Savi SmartChain platform automatically collects, centralizes, and intelligently publishes this information to satisfy customer requests and support better decision-making. Web applications are now becoming available that understand the complexities of the supply chain, replacing paperwork and erroneous data feeds with automation technology. Savi is leading the charge to provide an end-to-end solution that increases the profitability of the entire supply chain, not just one node of it.

Why Savi? With the world's most extensive real-time data collection network and software platform, Savi Technology leads the way to end-to-end supply chain collaboration and event management. Savi has over a decade of experience providing innovative solutions around the world to customers with very complex, global supply chains, such as the United States Armed Forces, Singapore Airlines, and IFCO Systems. With a reputation for working closely with multi-national shippers, logistics providers, and supply chain experts, Savi repeatedly proves that it understands supply chain issues, responds to customer needs, and provides practical and reliable solutions.

For More Information

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