Active RFID and its Big Future

Dr Peter Harrop
IDTechEx
Table 1.2  **Benefits and disadvantages of active RFID vs passive RFID**

<table>
<thead>
<tr>
<th>BENEFITS</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer range</td>
<td>Larger</td>
</tr>
<tr>
<td>Works in electrically noisy environments</td>
<td>More to go wrong – higher failure rate in use</td>
</tr>
<tr>
<td>Can transmit and/or process more complex data e.g. encrypted</td>
<td>Shorter life in use</td>
</tr>
<tr>
<td>Tag can initiate a message</td>
<td>Shorter shelf life</td>
</tr>
<tr>
<td>Smaller footprint for range of one meter or more</td>
<td>Battery may need recharging</td>
</tr>
<tr>
<td>Tag can incorporate a wide range of sensors and the chip can collate these data</td>
<td>More expensive</td>
</tr>
<tr>
<td>Practicable to choose from a wider range of frequencies</td>
<td>Less covert (tag may be detected initiating a signal)</td>
</tr>
<tr>
<td>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.</td>
<td>Heavier</td>
</tr>
<tr>
<td>An active tag can be used to interrogate a passive tag</td>
<td></td>
</tr>
<tr>
<td>Larger memory is manageable</td>
<td>Narrower temperature range than the best passive tags</td>
</tr>
<tr>
<td>Battery can drive other functions such as GPS or a display</td>
<td>Usually not an environmental product for disposal</td>
</tr>
<tr>
<td>Interrogator may be able to distinguish between tags without using anticollision algorithms in software e.g. better multitag reading is possible.</td>
<td>More likelihood of electrically interfering with sensitive equipment in e.g. hospitals or airports.</td>
</tr>
<tr>
<td>Tags may be able to talk to other tags e.g. to locate lost tagged items by forming an ad hoc network.</td>
<td>Greater privacy issues arise at the longer range that is possible</td>
</tr>
</tbody>
</table>

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 tag used for theft prevention on a laptop computer.

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

<table>
<thead>
<tr>
<th>Priority</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Tags</td>
<td>35.73%</td>
</tr>
<tr>
<td>Cost of Readers</td>
<td>5.87%</td>
</tr>
<tr>
<td>Total System Cost</td>
<td>22.13%</td>
</tr>
<tr>
<td>ROI</td>
<td>7.20%</td>
</tr>
<tr>
<td>Frequency of Operation</td>
<td>6.87%</td>
</tr>
<tr>
<td>Read distance</td>
<td>22.40%</td>
</tr>
</tbody>
</table>

Source: AIM
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.

Source Savi Technology

Figure 1.9 gives a military viewpoint of active RFID
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:
2.4.2. Los Angeles International Airport/ Long Beach USA – vehicle tolling and management

<table>
<thead>
<tr>
<th>Company</th>
<th>Application</th>
<th>Benefits Sought</th>
<th>Status</th>
<th>Tag</th>
<th>Supplier:</th>
<th>Format:</th>
<th>Interrogator:</th>
<th>System Integrator:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles International Airport</td>
<td>Passenger transport</td>
<td>Faster throughput</td>
<td>Roll-out (Complete)</td>
<td>Passive and active tags</td>
<td>TransCore etc</td>
<td>Passive and active tags</td>
<td>TransCore etc</td>
<td>TransCore etc</td>
</tr>
</tbody>
</table>

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
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 IDI), 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

<table>
<thead>
<tr>
<th>Company</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>HM Prison Service UK</td>
<td>Financial and security</td>
</tr>
<tr>
<td>Benefits Sought</td>
<td>Status</td>
</tr>
<tr>
<td>Crime prevention, Cost reduction</td>
<td>Roll-out (Ongoing)</td>
</tr>
<tr>
<td>Tag</td>
<td>System Integrator:</td>
</tr>
<tr>
<td>Supplier: Avonwood</td>
<td>Avonwood</td>
</tr>
<tr>
<td>Frequency: LF (132KHz)</td>
<td>System</td>
</tr>
<tr>
<td>Format: Active</td>
<td>Interrogator:</td>
</tr>
<tr>
<td>Read/Write: Card</td>
<td>Avonwood</td>
</tr>
<tr>
<td>Range: 1 meter</td>
<td>Further Information:</td>
</tr>
<tr>
<td></td>
<td>Avonwood: <a href="http://www.avonwood.co.uk">www.avonwood.co.uk</a></td>
</tr>
</tbody>
</table>

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.
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.
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
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.
Active RFID and its Big Future

Appendix 3: Achieving efficient global logistics

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 fulfillment 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 fulfillment 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 fulfillment center.
- Direct fulfillment from multiple warehouses at once, thus optimizing the use of each warehouse.
- Redirect long-lead orders to fulfill rush orders while still meeting expectations for the original order.
- Reduce rush-order transportation costs.
- Improve capital utilization.
- Enhance customer service and responsiveness.