AXCESS INTERNATIONAL INC.

# A Guide to Best-Fit Applications for Active RFID System Alternatives

# Introduction

Wireless systems have evolved to successfully penetrate the world of personal communications, where virtually all people can talk as needed on-demand with a feature rich and flexible set of alternatives. This world of people talking is now being complemented with a wireless world of all things “talking” – in other words, all things are becoming wireless. As these new systems continue to evolve to meet their best-fit applications in the enterprise, matching each one’s unique characteristics to the application is not always clear to the prospective end user or even to a providing system integrator.

Passive RFID system solutions are well known for their strengths and weaknesses in various tagging applications from access control to the supply chain. Active RFID/RTLS offers many more application opportunities for labor free automatic identification, counting, locating, sensing and protecting of assets; however, active RFID solutions today are being addressed using a handful of different system architectures. The mapping of best-fit characteristics for each is critical to achieving a workable system with the necessary reliability and at the lowest cost. What follows is a best-fit application analysis of the various active RFID system architecture alternatives for enterprise tagging solutions.

## The Foundation

Enterprise RFID systems can generally be categorized as either “passive” or “active,” with passive tags using the received signal for power and active tags using an embedded battery for power. Passive deployments typically occur in the high-frequency and ultra-high-frequency (HF/UHF) radio bands with applications such as the tracking of goods in the supply chain. They typically have low cost tags with higher cost infrastructures. Passive tag transmissions are also limited to the power of reflective (or backscatter) signaling and, as such, only transmit reliably in inches up to a few feet. The systems are characterized as fitting best in manual oriented auto-ID applications such as barcoding and today’s proximity-based access control cards. In addition, passive solutions use fixed portal infrastructures designed to automatically ID goods in the supply chain such as pallets, crates and cartons moving through the controlled portal.

On the other hand, active deployments are characterized by having the power to transmit over greater ranges with added flexibility in infrastructure design. Although active tags are typically more expensive than passive the infrastructures are less costly, and active deployments fit the need for automatic identification where no human involvement is needed or desired. The applications include asset tracking, personnel management, shipping container tracking and local vehicle management systems, all of which use a variety of frequencies.

There are variations on the typical standard passive and active deployments previously mentioned. Recent projects include passive tags that use batteries to improve their signal reception reliability, which is referred to as semi-passive. Additionally, developments in active tags are those based on the 802.11 standard, which can use off-the-shelf 802.11 wireless LANs for their main tag-to-reader transmission carrier. Meaning that active tags can operate in “beacon” mode, transmitting at regular intervals providing generalized location determination. Active systems can also use “computational positioning” to calculate a tag’s location based on signal measurements. “Control Point” systems have emerged as a preferred indoor location and control solution where tags can be activated on-demand at specific control-point locations using a second wireless frequency for wake-up rather than for transmission. These systems use dedicated sub-networks of receivers tied into the corporate net either wired or wireless.

Whether using a passive tagging system, active 802.11X or active “sub-networks,” today’s systems tag supply chain goods, large and small enterprise assets, personnel, local vehicles and finished goods as well as deliver wireless sensing providing total visibility to all things in the enterprise. Along with this extended edge-based visibility comes the addition of security related applications including the protection of assets, the safety of personnel and the access control and management of local vehicles.

## Passive RFID Systems

Passive RFID systems have historically been implemented for security and labor savings. Electronic Article Surveillance (EAS) systems began being used in the 1960’s to identify goods being stolen from retail stores. The simple transponder would signal an unpaid good if the tag had not been removed at the register. These types of systems have no resident unique ID or intelligence and require fixed, intrusive portal readers for reliable tag reading. To this day, they have not evolved to any useful role in enterprise RFID solutions.

In the 1990s personnel access control systems evolved to where identity cards could be presented within the proximity of a reader to gain door access rather than forcing personnel to swipe the card through a mag-stripe reader. This conversion of manual swipe to proximity presentation is a prime example of how passive RFID systems save the time required to swipe cards and the cost of maintaining reader machines. That paradigm could also be utilized to improve credit card payment and transportation ticket systems. In the enterprise today, Proximity Access Control is widespread; however, the short range nature of the cards prevents them from evolving to true automatic identification capability, so further improvements in labor savings and enhanced applications are unlikely. The enhanced applications now in demand include enterprise area (control zone) tracking for visitors and added internal security and employee safety including OSHA compliance and emergency evacuation.

In early 2000, passive systems took a new course toward automatic, hands-free identification of goods in the retail supply chain. Today, the Electronic Product Code (EPC) standard is being implemented on a large scale as an upgrade to barcode labeling systems with an eye to reduce counting errors and labor cost of identifying large volumes of goods passing through dock doors. EPC portals include fixed choke points where RF energy is transmitted from reader antenna. The small tag takes the energy, adds its ID and uses the bounce-back signal (called backscatter) to transmit to the reader for identification. These systems can be highly effective for counting high volumes of pallets, cases and cartons moving into a warehouse or distribution center.

The systems must be tuned to the environment to ensure reliable tag reads as often goods containing liquids or metals absorb the signal and prevent tag reads. This limitation makes these passive systems unreliable for other labor-less automatic identification applications in the enterprise including asset tracking and protection, wireless sensing and personnel access control and tracking. However, mobile manual systems can be employed to identify various types of assets more economically than barcoding, albeit still requiring labor to present a reader for a reliable tag read. Small, valuable items are most often tagged using this approach.

The automatic identification theme is being implemented on retail shelves to automatically track volumes ready for sale and those being sold. In this solution, small tags are attached to individual items; and as they are placed on the shelf and removed for sale, their inventory count is automatically changed. These systems are also being employed for choke point, point-of-sale automatic identification at cash registers for example. Retail Shelf Systems will remain well suited for item-level dispending. For example within the enterprise, this system was first seen in hospital drug dispensing methods where drug removal can automatically trigger billing and replenishment. While the tags are small and low in cost, they still suffer from the typical range limitations of passive systems.

The passive system architectures can therefore be summarized in three categories: Choke Point Systems, Shelf Management Systems and Proximity Access Control Systems.

## Active Systems

The overall growing demand for active RFID is reflective of a fundamental paradigm shift in the industry toward automated intelligence gathering and processing using smart, networked devices for enhanced visibility to enable the enterprise to be dramatically more secure, efficient and effective in support of automated business intelligence.

Further, as businesses become more geographically diverse to serve a fast growing global economy, the mobile workforce will continue to demand greater flexibility in workplace location. To deliver this flexibility, businesses must contend with the significant security challenges of protecting mobile assets and guaranteeing personnel safety across their enterprises. For example, lost information technology (IT) equipment such as laptops have become increasingly popular news items. Aside from the capital value of the equipment themselves, the information contained within can be exposed to the public. Depending on the sensitivity of the information, this can have far-reaching consequences. Enterprises can mitigate this problem by knowing both the real-time location and condition of assets as well as validating the credentials of people who enter buildings or visit corporate campuses. As an extension to securing a facility, personnel safety is also enhanced by knowing who is still in a building and where they are located during emergency evacuations. Asset and personnel visibility, safety and security combine to provide a dramatic ROI.

A wide variety of technologies do exist to deliver enterprise asset visibility, workforce and vehicle management and wireless sensing. However, choosing the right technology that works reliably with a best-of-breed corporate IT backbone is of paramount importance. These active RFID systems are often categorized as Real Time Location Systems (RTLS) as the basic function of locating people and things is at the core of RFID's benefits. There are two fundamental active RFID-RTLS system architectures: computational positioning and control point activation. An overview summary of active and passive architectures is presented in the following matrix.

*Table 1: Best-of-breed Technology for Enterprise RFID Application*

| Architecture | Computational Positioning | Control Point Activation | | Choke Points | Shelf Readers | Access Panel Readers |
|---|---|---|---|---|---|---|
| **Tag Technology** | Active Wide-Band | Active Narrow-Band | | Passive UHF | Passive Near-Field | |
| **Location Tracked** | Campuses & Buildings | Rooms & Closets | Portal Zones Entry/Exit | Conveyor Belts & Dock Doors | Shelves, Racks, POS | Access Control Zones |
| **Most Deployed Applications** | Network Access & Positioning | Asset Security & Sensor Networks | Access Control Credential & Security | Consumer Goods, Cases & Pallets | Items (Books, CDs, Tapes), e-Tickets | Credential Verification, Loyalty ID |
| **Frequencies** | 0.9 – 5.8 GHz | 315/433 MHz | | 860 – 960 MHz | 13.56 MHz | 100 – 150 KHz |

To identify best-fit applications to Active RFID and RTLS system architecture alternatives, a set of 12 evaluation criteria related to application reliability and cost has been created. They include the following:

1) Positioning method – The technique used for physically locating tags in and around a premises
2) Location error – The logical error rate in distance from the actual location
3) Tag read density – The number of tags that can be read at once
4) Control zone flexibility – The flexibility in establishing security location or positioning areas (or zones)
5) Tag form factors – The unique demands the architecture places on tag size and shape
6) Tag battery life – The prospective tag battery life based on the power demands of the architecture
7) Tag sleep option – The opportunity to have tags put in a sleep or quiescent state until needed whereby they do not transmit when not needed
8) ROI – The prospective ROI based on tag, infrastructure and software cost
9) Deployment time – The relative time to design and install a system
10) Infrastructure leverage – The relative ability to use existing network infrastructures
11) Interference – The degree to which the system is prone to interference thus effecting tag read reliability
12) Physical isolated sub-nets – The ability to use isolated sub-networks to avoid clogging of network backbone circuits

## Computational Positioning

Both *wide-area* and *local-area* real-time location systems (RTLS) have been developed to address asset and vehicle tracking, and personnel access control applications for enterprise buildings and campuses.

 

Wide-area RTLS systems include global positioning systems (GPS) and cellular positioning technologies such as Enhanced 911 (E911). These technologies generally work best for outdoor applications such as fleet management, automotive finished goods and road-way services. GPS remains unreliable in calculating locations inside and the system cost, and information transmission costs remain high relative to other solutions. These systems are, therefore, not

the most effective or cost-effective for asset management or personnel applications.

Local-area systems have been optimized for indoor and campus environments. Local area RTLS solutions can be further sub-divided into two types of systems: wide-band and narrow-band.

Common to these system approaches is the use of triangulation-based signal measurement approaches. Multiple approaches exist including simple signal strength (RSSI) comparisons, signal time difference of arrival (TDOA) and phase difference of arrival. All of these techniques suffer from either calculation errors related to signals bouncing off of objects and infrastructure or unworkable tag power consumption and battery drain. Consequently, computational positioning systems work best for outdoor applications.

## Wide-band RTLS Solutions

Wide-band solutions, such as Wi-Fi, leverage existing wireless local area network (WLAN) infrastructure for their operation. Location accuracy typically improves with the coverage density of deployed access points, but only to a certain point. Location accuracy is limited by radio frequency reflections called multi-path errors. In general, additional access points and software beyond that which is required for network connectivity must be installed to accommodate the positioning algorithms. For example, at least three access points will be required to determine location when relying on computational techniques referred to as triangulation or trilateration. These

| Parameters | Wi-Fi Tags |
|---|---|
| Positioning Method | Signal Strength Triangulation |
| Margin of Location Error | Tens of Feet |
| Density (Tags/Cubic-Meter) | Tens |
| Control Zone Size Flexibility | None |
| Form-Factor Constraints | Large Batteries |
| Battery Life (255 mA-H) | Locate 200K Times |
| On-Demand Wake-Up | No |
| Estimated ROI | Intermediate |
| Time to Deploy | Days (Site Surveys) |
| Signaling Reliability Issue | Signal Reflection Errors |
| Infrastructure Leverage | 802.11 w/ at least 3 AP |
| Interference Potential | High |
| Physically Isolated Sub-Nets | No |
| Applications | Generalized Asset Locating and Counting |
| Representative Vendors | Aeroscout, Ekahau, NEC, Pango (G2 Micro) |

computational technologies normally require the received signal strength indication (RSSI) or time-difference-of-arrival (TDOA) characteristics to be captured from the radio devices and processed by a more powerful computer. These systems are generally used for asset counting and general location applications where their accuracy is not critical to the savings derived. For example, large mobile assets subject to maintenance checks. Wide-band technologies provide higher speed connectivity to existing Wi-Fi infrastructures and, therefore, must utilize more power and a more complex air-interface protocol to ensure interoperability and reliability within a heavily utilized radio spectrum in the Industrial, Scientific and Medical (ISM) microwave bands. As a result, while existing infrastructure can be used, additions to it are required to the necessary area coverage. Tags utilize their power very inefficiently because they have to be compatible with wide-band systems designed more for data transport. Location accuracy is only generalized. No exact inside versus outside determination can be made, therefore, asset protection applications are not addressable.

## Ultra-Wideband (UWB) Systems

| Parameters | Wide-band/UWB Tags |
|---|---|
| Positioning Method | Time-of-Flight Triangulation |
| Margin of Location Error | Few Feet |
| Density (Tags/Cubic-Meter) | Tens |
| Control Zone Size Flexibility | None |
| Form-Factor Constraints | Special Wide-Band Antennas |
| Battery Life (255 mA-H) | Locate 2M Times |
| On-Demand Wake-Up | No |
| Estimated ROI | Very Long |
| Time to Deploy | Days (Site Surveys) |
| Signaling Reliability Issue | Microwave Absorption Errors |
| Infrastructure Leverage | FCC-only, EU Pending |
| Interference Potential | High |
| Physically Isolated Sub-Nets | Yes |
| Applications | Outdoor Campus Personnel Tracking, wireless sensing |
| Representative Vendors | Wherenet, Ubisense, Multi-Spectral, Crossbow (802.15.4), InnerWireless (Zigbee) |

In an attempt to get better location determination accuracy, Ultra-Wideband Systems utilize a broader frequency spectrum for a better signal measurement capability. Tag output is much greater and a more significant infrastructure is required. While the reliability of indoor positioning is still being tested, the ability to calculate precise locations outdoors does exist in a campus environment, for example. Some campus implementations have also included sensor monitoring.

## Narrow-band RTLS Solutions

Beaconing

Beacon-only systems are the most simple, yet least beneficial of the alternatives. Beaconing tags rely on receivers to pick up the signal and use simple signal strength measurement techniques (called Relative Signal Strength Indication or RSSI) to determine which receiver the tag is closest to. Each receiver has a coverage area typically up to 150 feet. As such, the tag's location is a gross generalization. Attempts to calculate tag location in near real time are difficult as frequent beaconing of, for example, one per second depletes the battery power pre-maturely, hampering the viability of the application. Beaconing tags also are viewed as RF polluters because of the unnecessary, constant transmissions. Applications best suited for this approach include asset inventory counting and large asset generalized location estimation; together with sensors the condition of fixed assets can be monitored.

| Parameters | UHF Beaconing Tags |
|---|---|
| Positioning Method | Signal Strength Triangulation |
| Margin of Location Error | Tens of Feet |
| Density (Tags/Cubic-Meter) | Hundreds |
| Control Zone Size Flexibility | None |
| Form-Factor Constraints | Chip Investment |
| Battery Life (255 mA-H) | Locate 3M times |
| On-Demand Wake-Up | No |
| Estimated ROI | Intermediate |
| Time to Deploy | Days (Site Surveys) |
| Signaling Reliability Issue | Signal Reflection Errors |
| Infrastructure Leverage | Fragmented (915, 868, 433) |
| Interference Potential | Medium |
| Physically Isolated Sub-Nets | Yes |
| Applications | Generalized Asset Locating and Counting |
| Representative Vendors | RF Code, Wavetrend, Identec, RF Technologies, Radianse, Sovereign, ID Systems |

Narrow-band solutions, such as products based on ActiveTag™ and Dot™ technologies from Axcess International, utilize low-cost and "light-weight" radio protocols to create high resolution "micro-cells" throughout a facility. These are suited for the wide variety of asset security and access control credential verification applications that are shown. Sub-nets of readers form the infrastructure that utilize existing wired or wireless network backbones.

As opposed to wideband technologies, narrow-band technologies such as active RFID, transmit at significantly lower power levels, utilize less complex and slower speed air-interface protocols and often operate in less cluttered license-free bands globally. Each technology type has benefits and deficiencies when considered for various applications.

Room Location Tag Activation Technology

The inherent inaccuracy of signal strength measurements for tag location has led to the addition of local activation techniques. Using infrared (IR), tags can be activated within rooms as IR signals are sent from room exciters and their light bounces off walls until they strike a tag. The IR signal carries a unique identifier so a tag in a given room can read the IR identification and report its room position. There are room size limitations to the technique, and IR cannot be used in open areas or to control perimeters. This technique does not enable perimeter control applications such as access control or asset protection, however, typical applications include inventory counts and personnel location positioning in hospital rooms.

Control Point Architectures

Again, basic Active RFID systems are architected for tags to transmit on a fixed interval to receivers for processing the tag ID. This beaconing approach as described earlier is characterized by tags transmitting in all directions (hence omni-directionally). While simple in concept, multiple active tags transmitting over a long range makes it difficult to differentiate one tagged object from another. Attempts to find a discrete tag are often made by trying to measure the signal strength of a tag signal to determine its location through its calculated distance from the receiver. However, as tag signals bounce off of objects and “bleed” into other receivers this type of approach is often suboptimal in certain applications.

For applications such as monitoring movement through defined portals, or for controlling access for people and tracking high value assets, tags are often awakened by specific radio signals, as opposed to beaconing on a constant basis. As equipment moves through a doorway for example, an activation signal is read by the tag and a response is generated to that signal. This is called a *control point* architecture because the tags can be located and related to their tagged objects at precise locations. So as multiple tags are activated, they can be identified precisely to a specific zone or control point. The ability to have tags beacon and also awakened on-demand is called “Dual-Active” operation.

When considering the appropriate RFID system design, one common requirement is to prevent RF bleed-over to adjacent areas such as portals or gates. Again, UHF signals propagate at large distances and also reflect off many surfaces. These signal bounces are very difficult to control, and they often activate tags in undesirable zones. Precisely controlling the dimensions of an RF interrogation zone and maximizing read range are fundamentally conflicting requirements for UHF only systems. The most often suggested solution is to lower the transmitted power. Unfortunately, doing so only reduces the range and robustness of the signaling.

This bleed-over problem is often addressed by careful placement and orientation of antennas, plus adding RF shielding materials to channel the energy. However, it is not always convenient, desirable or practical to place antennas in the physical location that results in best performance, nor is it cost effective to add RF shielding material to the installation. Another approach is to enhance the gain and directivity of the radiated signal with special antenna constructions. Unfortunately, this normally results in much larger, more costly antennas that are difficult to shelter from harsh environmental conditions or vandalism.

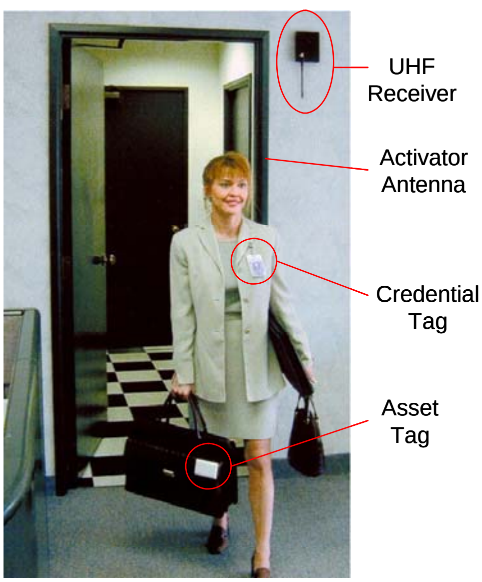


*Figure 1: Control point solution for Asset Protection and Personnel Security.*

Systems with dual-active operation address these conflicting requirements and deliver zone control and long range. Furthermore, with this architecture the antennas can be completely hidden from view, without changing the appearance of the original environment. This specific application is made possible by Axcess' control point architecture, consisting of Tags, Activators, Receivers, Middleware and Application Software.

Activators create activation zones only in the areas defined at installation. Flexible wire loop antennas generate a highly controlled 126 kHz magnetic field that robustly wakes up tags without causing any bleed-over into other control zones. The loop antennas can be wrapped around door frames, windows and ceiling tiles or simply placed under carpeting using a flat flexible printed antenna sheet. Activation zone size is adjusted dynamically to fit the physical environment.

Figure 1 is a photograph of an actual installation where *functional linkage* is applied to link a person to an asset, in this case a laptop in a briefcase. Antennas can also be buried under floor tiles, concrete and asphalt without any degradation in performance. The activator loop antenna in this photograph is installed around the door frame. The small palm-sized receiver is installed just above this doorway, but it can be installed anywhere within several dozens of feet range of the tag and serve multiple doorways.

Tags wake up from a deep power conservation state upon receiving the activation signaling. Therefore, power management for long battery life is fundamentally addressed at the architectural level, not just at the chip level. Unlike “beacon-only” technologies, Axcess’ Dot tags do not unnecessarily consume energy when they are outside activation zones. Although Dot tags also support a beacon mode, tags are normally configured to wake up only upon receiving an activation signal within the zones where they need to be read.

The activators transmit the zone threshold identification to activate tags. The tag recovers the location ID, adds a status code plus its unique identification and transmits a UHF packet to hidden palm-sized receivers some distance away. Therefore, each tag transmission carries a message as to *exactly* which activator awakened it. Tag location is precisely related to the threshold of the activator location. The UHF receiver recovers this packet and then adds its unique identification before sending the aggregated information packet to middleware and application software that connect to the enterprise network.

Many applications can be successfully fielded with the control point architecture. Utilizing the power on board the active tags with unobtrusive activators and receivers allows for significant flexibility for tagging people, assets and vehicles. Because the control point architecture provides rapid, precise location determination it is unique in supporting perimeter “in versus out” needs such as access control, asset protection, internal security zones, emergency evacuation, asset to custodian assignments and sensor-based condition monitoring.  In total, these can be explained within the concept of delivering “edge intelligence” to the corporation.

| Parameters | ISO18000-7 | Dual-Active |
|---|---|---|
| Positioning Method | Sign-post Triggers | Control Point Architecture |
| Margin of Location Error | Negligible within Zone | Negligible within Zone |
| Density (Tags/Cubic-Meter) | Hundreds | Thousands |
| Control Zone Size Flexibility | Scalable | Scalable |
| Form-Factor Constraints | Chip Investment | Chip Investment |
| Battery Life (255 mA-H) | Locate 2M Times | Locate 6M Times |
| On-Demand Wake-Up | Yes | Yes |
| Estimated ROI | Long | Short |
| Time to Deploy | Hours | Hours |
| Signaling Reliability Issue | Nothing Significant | Nothing Significant |
| Infrastructure Leverage | Mostly Military Use | 126 kHz, 433 MHz world-wide |
| Interference Potential | Low | Low |
| Physically Isolated Sub-Nets | Yes | Yes |
| Applications | Container Tagging | Personnel access control, tracking and emergency evac., Asset Location, counting, and protection, Vehicle access control and status, payload Inventory, Sensor data collection |
| Representative Vendors | Savi Technologies | Axcess |

## Deriving Edge Intelligence from Control Point Architectures

Additional functionality can be provided at different levels of the AXCESS control point architecture. For example, when multiple control zones are installed at both the outside and inside areas of a room or doorway, the system will also provide travel direction data. Although direction of travel can be inferred at a macro-level over time by tracking activity at various control points, the Axcess solution provides true edge intelligence that facilitates real-time decisions and response at the point of activity.

The system is capable of responding in real-time at the enterprise edge based on logic incorporated at the receiver. For example, the receiver can be configured to activate local relays to control locks, lights, buzzers or motors when specific tag conditions exist or when specific tags are seen. Dot tags also support a wide variety of transducers to sense physical characteristics such as temperature, vibration, radiation and chemical substances. Tags can be programmed to transmit an alert condition to the Axcess receiver when the sensed phenomenon exceeds a predetermined threshold. Edge logic in the receiver or business logic in the middleware can then take appropriate action in real-time. In so doing, the system avoids network latencies by avoiding consultation with centralized intelligence on a remote server.

The Axcess middleware utilizes a patented feature called *functional linkage* to logically associate different tags. This allows the system to generate multiple forms of alerts (e.g. emails, SMS messages, audible alarms), for example, when a person carrying a personnel badge/tag (or none at all) leaves the building with an unauthorized laptop containing an asset tag.

The Axcess dual-active solution, consisting of control zone activation and long range UHF transmission constitute the patented dual-active approach that addresses tough requirements for low-cost, reliable performance, concealed installation and flexibility in deployment.

 

## Active Architecture System Characteristics Comparison Summary

| | Computational Positioning | | | Control Point Architecture | |
|---|---|---|---|---|---|
| Parameters | Wi-Fi Tags | Wide-band/UWB Tags | UHF Beaconing Tags | ISO18000-7 | Dual-Active |
| Positioning Method | Signal Strength Triangulation | Time-of-Flight Triangulation | Signal Strength Triangulation | Sign-post Triggers | Control Point Architecture |
| Margin of Location Error | Tens of Feet | Few Feet | Tens of Feet | Negligible within Zone | Negligible within Zone |
| Density (Tags/Cubic-Meter) | Tens | Tens | Hundreds | Hundreds | Thousands |
| Control Zone Size Flexibility | None | None | None | Scalable | Scalable |
| Form-Factor Constraints | Large Batteries | Special Wide-Band Antennas | Chip Investment | Chip Investment | Chip Investment |
| Battery Life (255 mA-H) | Locate 200K Times | Locate 2M Times | Locate 3M times | Locate 2M Times | Locate 6M Times |
| On-Demand Wake-Up | No | No | No | Yes | Yes |
| Estimated ROI | Intermediate | Very Long | Intermediate | Long | Short |
| Time to Deploy | Days (Site Surveys) | Days (Site Surveys) | Days (Site Surveys) | Hours | Hours |
| Signaling Reliability Issue | Signal Reflection Errors | Microwave Absorption Errors | Signal Reflection Errors | Nothing Significant | Nothing Significant |
| Infrastructure Leverage | 802.11 W at least 3 AP | FCC-only, EU Pending | Fragmented (915, 868, 433) | Mostly Military Use | 126 kHz, 433 MHz world-wide |
| Interference Potential | High | High | Medium | Low | Low |
| Physically Isolated Sub-Nets | No | Yes | Yes | Yes | Yes |
| Applications | Generalized Asset Locating and Counting | Outdoor Campus Personnel Tracking, wireless sensing | Generalized Asset Locating and Counting | Container Tagging | Personnel access control, tracking and emergency evac., Asset Location, counting, and protection, Vehicle access control and status, payload Inventory, Sensor data collection |

## Conclusions

The overall growing demand for active RFID is reflective of a fundamental paradigm shift in the industry toward automated intelligence using smart, networked devices that provide business intelligence, based on enhanced visibility to enable the enterprise to be dramatically more secure, efficient and effective.

A wide variety of technologies do exist to deliver enterprise asset visibility and personnel security. However, choosing the right technology that works reliably with a best-of-breed corporate IT backbone is of paramount importance. RFID "sub-networks" can be seamlessly implemented to tag assets, personnel and vehicles providing total visibility to all things in the enterprise. Along with this extended edge-based visibility comes the addition of security related applications including the protection of assets and the access control of personnel and vehicles.

## About AXCESS International Inc.

Axcess International Inc. (OTCBB: AXSI) delivers wireless intelligence through real time business activity monitoring solutions that improve productivity, security and revenue growth. The systems derive wireless intelligence from automatic advanced WKM, workflow management, asset monitoring and distributed sensing. Its revolutionary and patented Dot micro-wireless technology platform combines RFID, RTLS and wireless sensing for better decision-making and control throughout the enterprise. Axcess is a portfolio company of Amphion Innovations plc (AIM: AMP). For additional information on Axcess, visit www.axcessinc.com.

## About the Author

Allan Griebenow is President and CEO of Axcess International Inc. (OTCBB:AXSI), which delivers wireless intelligence through real time business activity monitoring solutions that improve productivity, security and revenue growth. Previously, he ran Prism Video Inc., a pioneer in compressed, digital video security systems. He was President and CEO of Vortech Data, which provided network-based medical image communication systems before being acquired by Kodak Health Imaging Systems in 1992. He started his career in the late 1970s as a presidential management intern with NASA's Office of Aeronautics and Space Technology. He holds a B.S. in Business Administration from the University of Maryland and an MBA from San Francisco State University.

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