OFFICE OF INSPECTOR GENERAL
UNITED STATES POSTAL SERVICE

WHITE PAPER

Enriching Postal Information: Applications for Tomorrow's Technologies

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EXECUTIVE SUMMARY

Enriching Postal Information: Applications for Tomorrow's Technologies

The widespread use of computers, smart devices, and online social networking has marked the beginning of the Information Age. This Age has connected entities, removed geographic boundaries, changed how we communicate and transact, and created new expectations for the future marketplace. Supply of and demand for immediate information has disrupted traditional roles, empowered consumers, and enabled internal efficiencies. Instant information is the new normal for the world, even in the mailing sector.

Highlights

The Postal Service has a critical role in delivering physical mail; however, information about the mail is now just as important as the mail piece itself.

The market needs for information drive strategic and investment decisions. These decisions drive the technology and integration that lead to the development of customer-centric applications.

Interestingly, industry leaders in the information business are technology neutral; the pursuit of technology serves only as the means to meet customer needs.

Applications based on the Postal Service's carrier network, vehicle fleet, and Post Office network could provide core customer-centric applications, such as a mobile post office.

For more than 235 years, the Postal Service has connected senders and recipients by delivering physical mail pieces. Today, the Postal Service delivers 160 billion pieces of mail per year; however, information about physical mail is now just as important as the mail piece itself. Mailers and consumers seek real-time information on postal products and services such as tracking and tracing of parcels and new capabilities like directing the place, date, and time of delivery. Postal management could use that information to prevent service failures, align staffing and equipment to workload, increase workplace safety, and decrease mail theft. Information could also unlock additional capabilities for the public ranging from identity verification services to secure government transactions. Postal sensor nets could assist with real-time mapping and traffic monitoring.

Industry leaders have adopted several common practices to provide this information. They first commit to a long-term, strategic decision and investment based on customer needs. Then, they research and invest in the appropriate information-gathering

technologies, such as mobile handhelds, barcodes, or Radio Frequency Identification (RFID) tags. Interestingly, industry leaders are technology neutral and view it simply as a means to meet market needs. The OIG worked with IBM to research a variety of tracking technologies and highlight those most relevant to the postal industry. After integration within the business, the last, and perhaps most important, practice is developing customer-centric applications.

These applications address a wide range of external customers' needs and internal operational needs. This paper lists more than 50 potential applications focused on sales, transportation, en-route operations, customer service, delivery and last mile, and safety and security. The paper combines several applications into focus areas based on the Postal Service's competencies and strengths including its carrier network, vehicle fleet, and Post Office network. These focus areas of mobile post offices, citizen services, vehicle-related services, safety, real-time services, and internal operations could be developed on a faster track.

The demand for mail products and services is evolving quickly in the Information Age. The Postal Service has a critical role, not only connecting senders and recipients with physical mail and parcels, but also by providing the digital information and information-based services that businesses and citizens need. By increasing its investment in the necessary technology and integration, gathering value-added information, and delivering customer-centric applications, the Postal Service can position itself to succeed in the information business.

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Enriching Postal Information: Applications for Tomorrow's Technologies

Introduction

The Information Age has ushered in an ever-increasing amount of information into everyday life. The emergence of collection technology, social media, analytics, smartphones, and cloud computing has redefined the value proposition for traditional postal and delivery services. Customers are demanding instant access to near real-time information on every delivery and are willing to pay a premium for these services. Postal administrators and private shippers are deploying new technologies to allow tracking information about all mail — from postcards to packages. These technologies gather data that can be transformed to valuable information for both operations and customers. Shipping companies can control costs and synchronize operations, while the information makes e-commerce, correspondence, and transactions easier for customers. Posts courageous enough to explore innovative ways to engage this information will provide immense public good and customer value.

This paper suggests that the Postal Service must quickly adjust its strategies and technologies to become a stronger competitor in this "information business." The Postal Service can do so by re-envisioning itself as not only a mail delivery service, but also an equally important information platform. This information would include a wide range of traditional shipping data such as addresses, internal operating data, logistics, billing, and returns. In addition, the Postal Service could also provide information-based services demanded by the public such as identity authentication, weather conditions, current traffic flow, and more. The Postal Service possesses strengths and advantages to gather this information. Assets such as its vast fleet of vehicles and the relationship between its carriers and households are unmatched.

The Postal Service has traditionally invested in technology to gather and provide mail information. One such example is the Intelligent Mail Barcode (IMb®). The IMb provides valuable information about the mail piece, such as the destination address and mail type, and can provide status updates to mailers and the Postal Service. However, merely gathering and providing this information does not necessarily add value for customers. To add value, the information must be presented through applications that customers can use easily and that meet customers' needs.

With the proper strategic approach, the Postal Service can reposition itself to meet the growing customer needs in the information business. Imagine if the Postal Service could provide customers the flexibility to cater their deliveries to their desires. The Postal Service of the future could be the face of government by offering a variety of services like identity verification via its carrier network. The Postal Service could use superior analytics to automatically change the route of any mail piece. To better envision what

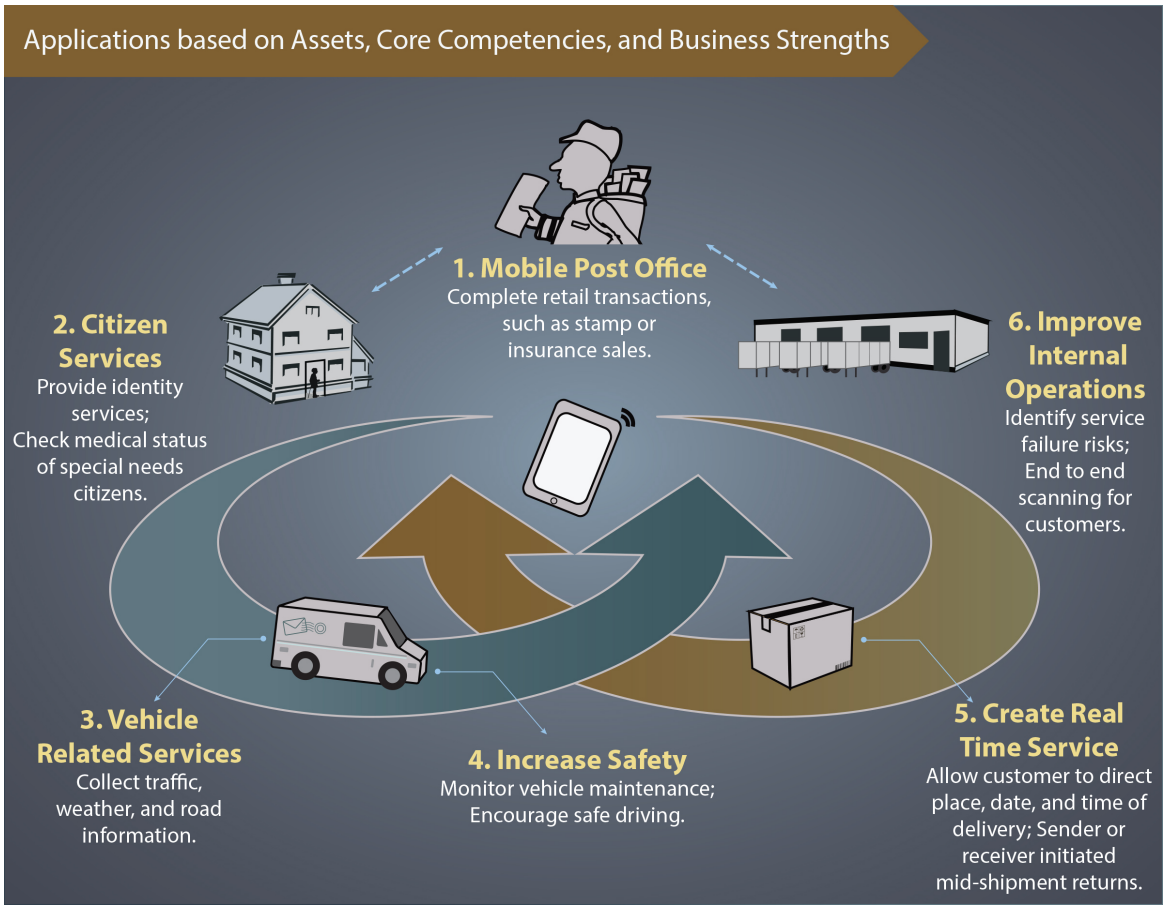
the Postal Service of the future might look like, we start by discussing some of the creative end user applications this information can provide.

Applications

The mail delivery companies that successfully evolved into information businesses demonstrate one shared trait — a commitment to develop customer-centric solutions. Compelled by unrelated circumstances, these companies use different technologies and gather different data. However, they all successfully developed customer-centric applications that made information easily accessible and met customer needs.

The Postal Service could begin developing initial applications based on its assets, core competencies, and business strengths, such as its carrier network, vehicle fleet, consistency of delivery six days a week, and ubiquitous Post Office network. Figure 1 highlights six initial focus areas for applications derived from these business strengths, assets, and core competencies and is followed by a detailed discussion of each. Appendix A provides a more extensive list of potential applications.[1]

Figure 1: Six Initial Focus Areas for Postal Service Applications



[1] The OIG and IBM brainstormed the full applications list available in Appendix A and then selected some for further discussion in this section.

Focus Area #1: Mobile Post Office

One of the Postal Service's biggest strengths is its carrier network. Six days a week, over 200,000 postal carriers connect American households and businesses. Applications that enhance the interactions between carriers and postal customers are a logical opportunity to develop customer-centric information-based applications.

Many of us know our postal carriers. The same carrier arrives at our door or mailbox, delivers our mail, drops off and scans our packages, and leaves attempted delivery notices in our absence. Now imagine the digitally connected and enabled carrier of the future — who uses a mobile information device, similar to an iPad, equipped with applications that provide services previously available at the local post office, like purchasing stamps, escrow payment services, digital collect-on-delivery services, or passport services.[5] This device might even change the way we ship packages — imagine if the carrier could debit the correct postage from your established account when they scan and accept your package at your doorstep. This new approach allows the Postal Service to meet its mission of 'binding the nation together' through offering postal services where and when customers need them and providing opportunities for new products and services.

A Closer Look: Mobile Handhelds

Mobile hand-held devices are nothing new for delivery service companies. United Parcel Service (UPS) used its first hand-held device in 1991.[2] The Postal Service followed shortly after in 1997.[3] Today, these types of devices can do much more than their predecessors. France's postal service, La Poste, is currently piloting a smartphone to enable new customer service offerings including identity authentication.[4]

The Postal Service is exploring the potential of mobile devices. For example, it recently gave cell phones, capable of texting and collecting real-time GPS data, to about 95 percent of its street letter carriers, which should improve these carriers' delivery efficiencies. However, cell phones are simply a temporary bridge to the eventual solution of full-service mobile devices, such as "smart

[2] "The Evolution of the UPS Delivery Information Acquisition Device (DIAD)," *UPS,* http://pressroom.ups.com/Fact+Sheets/The+Evolution+of+the+UPS+Delivery+Information+Acquisition+Device+(DIAD).

[3] "Hand Held Products Mobile Computers and Barcode Scanners," *emkat,* 2013, http://www.emkat.com/hand-held-products.asp.

[4] "La Poste develops smartphone for carriers, launches interactive delivery," *Post and Parcel,* February 26, 2013, http://postandparcel.info/54015/news/it/la-poste-develops-smartphone-for-carriers-launches-interactive-delivery/.

[5] U.S. Postal Service Office of Inspector General, *Peer-to-Peer Commerce and the Role of the Postal Service*, Report No. RARC-WP-13-005, January 14, 2013, https://www.uspsoig.gov/sites/default/files/document-library/2013/rarc-wp-13-005.pdf. These services are discussed further in this paper on peer-to-peer commerce.

radios" or iPads, for all carriers. The Postal Service is currently planning to procure and deploy 75,000 full-service devices by the summer of 2014.

Focus Area #2: Citizen Services

In addition to providing new ways to deliver existing services, carriers could also offer new services via mobile devices, such as verifying an individual's identity by synchronizing with government databases. Online identity verification is an integral missing link necessary to protect the public over the Internet, yet there is no easy and secure way to verify online identities.[6] In Europe, posts are leveraging their trusted brands to become the secure digital faces of government and to provide citizens with channels to complete secure digital transactions like benefits payments and identity authentication.[7] The Postal Service could connect the 15 percent of American adults who do not use the Internet or further protect the citizens who already use the Internet by providing secure payment choices or other options at the doorsteps of citizens.[8] La Poste is currently exploring whether carriers could perform simple medical tests such as obtaining weight and blood pressure for residents of sparsely populated rural areas. The Postal Service should strengthen its historic and valuable position as the face of government here, and explore alternative citizen services through its massive carrier network.

Focus Area #3: Vehicle Related Services

The Postal Service's 212,530 vehicles covering 1.3 billion miles every year represent one of the largest civilian fleets in the world.[9] The Postal Service could leverage this asset to provide useful information externally to the public and businesses, while improving internal operations. This information, such as information about street signs or construction zones, can prove invaluable to drivers navigating roadways and parking their cars. Notably, Google's recent purchase of Waze for $1 billion highlights the value of this type of information.[10] Waze relies on input from its users to gather information about accidents, traffic, or other driving information. It then supplies this information through driving-direction applications or other means.

What is preventing the Postal Service from passively collecting similar or new information not provided elsewhere through its vast carrier vehicle network and sharing it through applications with information service providers? With information-gathering technology, the Postal Service could provide live data on traffic or new information as this field grows exponentially. In fact, Deutsche Post DHL leveraged its fleet to provide

[6] U.S. Postal Service Office of Inspector General, *Digital Identity: Opportunities for the Postal Service*, Report No. RARC-WP-12-011, May 29, 2012, http://www.uspsoig.gov/sites/default/files/document-library-files/2013/RARC-WP-12-011.pdf.
[7] "Digital Agenda for Europe," *European Commission,* 2013, http://ec.europa.eu/digital-agenda/en.
[8] Kathryn Zickuhr, *Who's not online and why,* Pew Research Center, September 25, 2013, http://pewinternet.org/Reports/2013/Non-internet-users.aspx.
[9] "Postal Facts," *United States Postal Service,* 2013, http://about.usps.com/who-we-are/postal-facts/.
[10] Peter Cohan, "Four Reasons Google Bought Waze," *Forbes,* June 11, 2013, http://www.forbes.com/sites/petercohan/2013/06/11/four-reasons-for-google-to-buy-waze/.

real time street-level information.[11] Traffic volume is not the only potentially valuable data: the Postal Service could also gather local weather information, detect hazardous gas or radiation leaks, and even measure the availability of broadband or wireless services in order to identify service availability.[12]

Focus Area #4: Increase Safety and Reduce Costs

In addition to providing information to the public, upgrading its fleet of vehicles with information-gathering technology could also benefit the Postal Service internally. For example, Purolator Courier, the package shipment company in Canada, uses such technology to monitor the time of delivery stops throughout the day to identify carriers who were given too much or too little work; workloads are then rebalanced. Purolator Courier also examines deliveries that take longer than average. This information can identify neighborhoods or groups of locations that cost more than average to provide delivery service and can aid posts in identifying potential locations for cluster boxes.[13] Another example is the UPS use of data to monitor its drivers' behaviors to increase

A Closer Look: Information Obsessed, Technology Neutral

UPS is a leading information and technology innovator within the package delivery business. Yet, the company uses antiquated barcode technology just like the Postal Service. So, why is UPS so highly regarded?

UPS understands that technology and information are only as useful as the applications that help its customers. Customers can schedule their delivery within a 2-hour window and effortlessly keep track of each package because UPS sends notifications of the pickup, en-route status, and delivery to customers' email or mobile devices.

UPS builds applications using analytics to drive its own business decisions. These applications reduce costly delivery-rescheduling by accounting for customer availability when planning routes. UPS's investments in the proactive status notification systems for its customers also reduce internal costs by reducing the number of customer call inquiries. UPS uses analytics to determine the ideal layout when loading each delivery vehicle.

Customers likely perceive UPS as the leading information and technology company because UPS designs its applications around its customers' needs and then communicates their commitment and the availability of their customer-centric applications to the public and its customers.

[11] IBM interview with DP/DHL Team.
[12] Michael J. Ravnitzky, "Offering Sensor Network Services Using the Postal Delivery Vehicle Fleet," (presented at the 18th Conference on Postal and Delivery Economics, Porvoo, Finland, June 4, 2010), http://www.prc.gov/(S(15nbeh553nkk0xrme4etk0vd))/prc-docs/newsroom/techpapers/Ravnitzky%20Postal%20Sensors%20Paper%20070910-MJR-1_1191.pdf.
[13] IBM interview with Purolator Courier team.

seat belt use, reduce speeding, and reduce aggressive driving, thereby reducing injuries and overall workers' compensation costs. For instance, UPS analyzed GPS-enabled vehicle movement data to determine that a vehicle backing up was the most risky maneuver their drivers perform; the company then sought to eliminate these moves.[14] Considering that the cost of workers' compensation for the Postal Service was $3.7 billion in 2012 and that 36 percent of those injury costs come from injuries to carriers, these applications could be of great value to the Postal Service.[15] These same types of technologies could additionally provide information about vehicles to help manage delivery scheduling and preventative maintenance.

Focus Area #5: Create Real-Time Service

The Postal Service provides a critical service by connecting senders to receivers through mail. Accessible analytics can greatly enhance this service. Currently, the Postal Service collects and provides a lot of information about mail. Yet, there is an increasing opportunity to satisfy customers' needs and internal operational needs through new customer-centric applications and analytics.

Mail service companies now provide automated status and progress updates to customers through email or text messages. UPS sends automated updates to customers' email for 99.7 percent of its packages and DHL's tracking application provides status updates in real time, which enables employees to track time sensitive shipments and adapt their planning accordingly.[16] Comparably, the Postal Service currently provides status updates that a customer can look up online for about 90-95 percent of its packages.

Beyond basic tracking, customers increasingly want the ability to do something else with this information, such as redirecting deliveries, performing mid-shipment returns, and other customized delivery options. For example, 24 percent of consumers want to be able to specify their delivery windows. Another 15 percent want to receive a text message when their mail arrives.[17] These customer-centric type applications are possible, and rely heavily on first obtaining the data necessary to feed these applications.

Focus Area #6: Improve Internal Operations

The information to create applications for internal use already exists for most of the mail. However, current Postal Service applications mainly function as passive indicators that alert employees only if the employee actively checks on the information. In today's information overload environment, this active interaction with passive applications might be impractical. Instead, the Postal Service could actively identify mail at risk of missing

[14] IBM interview with UPS.
[15] "Neither Rain Nor Sleet But Dog Bites: Post Office Workers' Injury Claims," *Insurance Journal,* September 27, 2013, http://www.insurancejournal.com/news/national/2013/09/27/306440.htm.
[16] "DHL app simplifies worldwide logistics management," *DHL,* July 25, 2013, http://www.dhl.com/en/press/releases/releases_2013/logistics/dhl_app_simplifies_worldwide_logistics_management.html#.UkWxjHcw2ys.
[17] Boston Consulting Group, *Same-Day Delivery*, March 2013, p. 10.

service or transportation connections and actively alert employees through a real time application. Further, applications could actively notify processing plant employees when traffic or weather delays trucks.

These six initial focus areas for applications illustrate the output from an information business approach that recognizes customer needs, strategically outlines an approach to meet those needs, and then utilizes technology that allows the application development. We now explore the customer needs driving the demand for these applications.

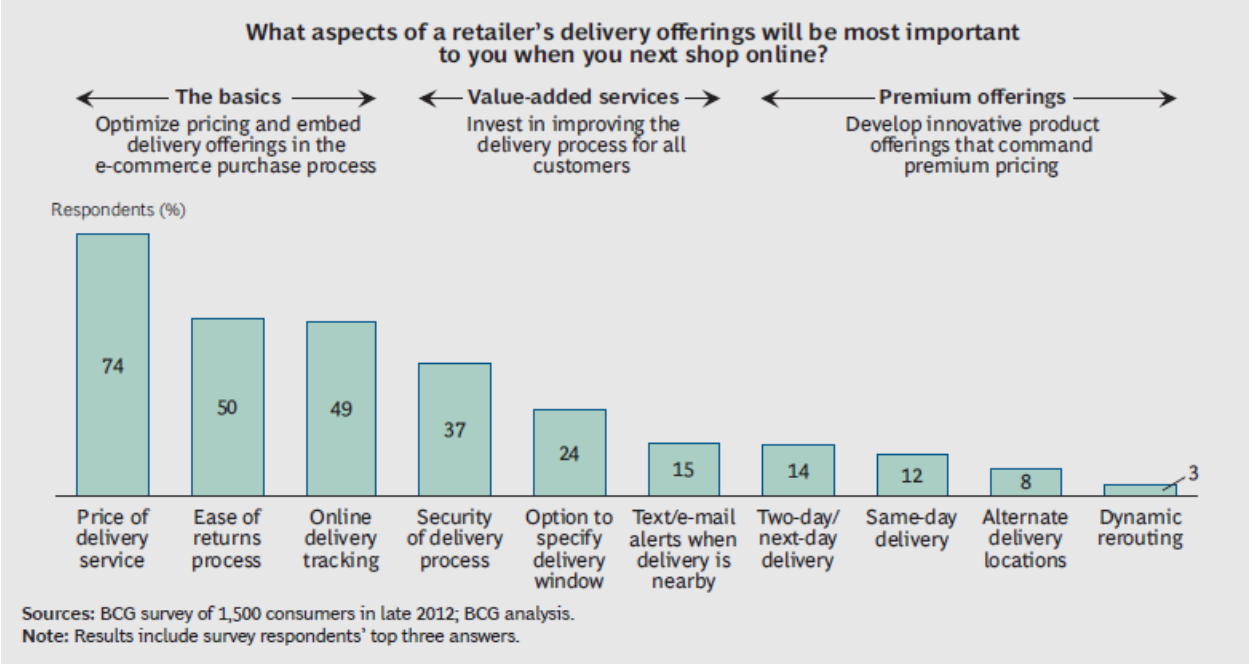
Market Demands

External Demands

The Postal Service first started tracking mail for internal quality control use. At that time, customers desired mail service more than mail tracking information; customers viewed tracking information as a marginally valuable extra service. Yet recently, information about mail shipments has become the baseline expectation.[18]

Many studies document this shift. As shown in Figure 2, 49 percent of consumers found online delivery tracking to be most important to them when shopping online.[19]

Figure 2: The Importance of Tracking to Consumers



Source: Boston Consulting Group, March 2013, *Same-Day Delivery*, page 10.

[18] OIG's prior paper, State of the Mail, discussed this increase in information demand by consumers.
[19] Boston Consulting Group, *Same-Day Delivery*, p. 10.

Another study found that the following five factors significantly influenced customers' shipping choice:

1) Tracking ability
2) Delivery options
3) Duration and reliability
4) Return service
5) Price[20]

These studies document how tracking became the expected norm; delivery options are soon to follow. Consumers want more control over their delivery experience — particularly a choice of date, time, and location of delivery.[21] Information leaders are responding by providing more delivery options. Competitors' customers can choose where to have their packages or mail delivered: parcel locker, their home, or their office.[22] SoPost is a recent startup company that takes these options one step further and aims to link consumers' online profiles to their home, work, and other physical addresses. This concept provides more choice to consumers as to where to send their mail and purchases while reducing redelivery costs and customer service calls for posts.[23] All of these initiatives highlight companies responding to customer demands for increased delivery options.

A Closer Look: The Customer is Always Right

In 2007, Purolator Courier had a problem. One of its biggest customers was about to walk away, because Purolator's tracking information was not keeping up with the customer needs. Purolator had to decide — let this one customer go, or compete and invest in the future?

Purolator wisely went with the latter choice and expanded their information services. They launched a new logistics return service designed to automate the return process, reduce costs and errors, minimize crowding in business warehouses, and evaluate their customers' return habits. Purolator not only kept this one customer, but also transformed its capabilities to meet emerging market demands and its own internal needs.

Consumers want to receive their online purchases with ease. In fact, consumers are willing to provide as much information as possible to their delivery providers to ensure successful delivery.[24] This enviable circumstance is an opportunity for the Postal Service to establish a stronger relationship with its customers; also, this would likely increase customer adoption of applications and solutions.

Not only do consumers demand mail information, but businesses are even more data hungry. Businesses demand mail tracking information, including delivery confirmation,

[20] International Post Corporation., *IPC Cross-Border E-Commerce Report,* 2010, p. 27.
[21] United Parcel Service, *UPS Pulse of the Online Shopper*, May 2013, p. 6.
[22] UPS' service is named 'UPS Delivery Intercept.' FedEx's service is named 'FedEx Delivery Manager.'
[23] Steve O'Hear, "Crazy-Stupid Or The Future? SoPost Wants To Turn Your Twitter Handle Into A Physical Address," *TechCrunch,* December 3, 2012, http://techcrunch.com/2012/12/03/sopost/.
[24] IBM, *Winning Over the Empowered Consumer,* April 2012, p. 7 and Consumer Focus Scotland, *'Effective parcel delivery in the online era,'* August 2012, p. 6.

barcode scans, and logistics support. Many businesses do not consider the Postal Service's tracking information services adequate. According to a survey of industry shippers, 41 percent of those who answered said they would not consider the Postal Service a viable alternative to FedEx or UPS for Ground Services. Furthermore, 55 percent said the Postal Service was not an alternative for Air or Express Services.[25]

Credibility and brand reputation would greatly benefit from enhanced mail tracking capabilities. The marketplace perception is that competitors are more technologically advanced than the Postal Service and are much better at tracking and tracing shipments. For example, a commonly used consumer review website claims that the "Postal Service falls short when it comes to the ability to track packages; the USPS website just can't give you the type of detailed tracking provided by FedEx and UPS."[26] In addition, some businesses concur. According to a freight consultant: "USPS has a lack of guaranteed time delivery, inferior tracking system, lack of trust when it comes to more expensive, time-sensitive items."[27] Whether this perception is warranted is irrelevant — the perception is costing the Postal Service an immeasurable amount of business and hurting the Postal Service's brand and reputation.

Internal Demands

Accurate tracking information for 100 percent of mail could immediately increase Postal Service operational efficiencies, prevent service failures, optimize new costing methods, and improve law enforcement.

Efficiency of operations would improve if applications actively informed employees of mail status. For example, currently, if a truck going from one plant to another is late, the information of the exact amount of mail on that truck and delivery zones it contains can be looked up manually in systems but is tedious and not practical. The Postal Service would benefit from an active notification system of mail status so that management could adjust the operations to still meet service requirements.

Tracking and mail information would enhance law enforcement by providing more information about mail flow and patterns. Law enforcement could detect patterns of missing mail in the operation flow to detect potential fraud. Internal postal operations could be analyzed to find operation groups where mail disappears. Externally, clusters of delivery addresses and undelivered reports could be analyzed to determine potential mail thefts.

Lastly, tracking information could unlock unforeseen uses, applications, and possibilities. Innovations are largely a by-product of the use of breakthrough technology such as the telephone, Internet, or personal computer. Historically, the Postal Service has been an innovator through creative experiments with airmail delivery, the ZIP Code (Zone Improvement Plan), and optical character recognition technology. By sharing

[25] Martinez, Rob, *Parcel Pricing Survey – Results Unveiled*, www.ParcelIndustry.com/media/PublicationsArticle/Final_Survey.pdf, October 2011.
[26] "Shipping Companies: Reviews," *Consumersearch,* 2013, http://www.consumersearch.com/shipping-companies.
[27] Parry, Tim, *Why USPS is a viable alternative to FedEx and UPS*, January 23, 2013.

these ideas with the public and allowing free use of their capabilities, these applications led to the expansion of completely unforeseen business models and greatly contributed to the national GDP.[28] Tracking the mail offers another opportunity for the Postal Service to inspire the innovators and entrepreneurs of our nation.

Strategic Decision

Industry leaders in the information business exhibit some commonalities and best practices. To serve its mandate and meet the changing needs of the mail, the Postal Service could adopt some of the strategies of its peers and competitors.

Industry leaders uniformly recognized and responded to market needs. They met those needs by using cost effective technologies that met the requirements of the customers. Leaders developed a well thought out strategic approach, researched to meet those needs, integrated the data from those technologies, and finally developed customer-centric applications.

The leaders recognized these inputs change continuously and re-examined their strategies for each aspect regularly. This allows the leaders to meet market needs and even give an appearance of technological superiority when in fact they are using the same technology as the Postal Service. Below we examine the best practices from industry leaders for each aspect of the continuous cycle of development.

A Closer Look: Amazon's Culture of Commitment

Founded in 1994, Amazon is one of the most successful Internet startup companies. One reason behind Amazon's success is its approach and corporate commitment to customer-oriented application development. Amazon's website suggests additional items customers may want to purchase based on information the customers provide and their purchase history. Amazon developed a corporate culture that "reflected its drive to innovate as well as its focus on customer satisfaction. Developers were encouraged to focus on the value added to customers rather than just adapting new technology. Amazon strives to be the world's most accessible and customer-centric company."[29]

- Market needs drive the entire cycle – Market needs are constantly changing. As observed in our research, customers initially regarded tracking information as an extra service only a few years ago, but now expect it in the basic mail service. Currently, customers view delivery options as an extra service and will pay extra, but soon may also expect the ability to choose delivery options as included in their mail service. Leaders in the information business consistently re-examine

[28] U.S. Postal Service Office of Inspector General. *The Untold Story of the ZIP Code.* April 1, 2013. RARC-WP-13-006.
[29] *Amazon Enters the Cloud Computing Business*, Micah Siegel and Fred Gibbons, Stanford University School of Engineering, 2008, p. 3.

the market needs and then strategically act with an appropriate response to stay ahead of the demands.

- Today's technologies are tomorrow's discards – Industry leaders consistently research and invest in technologies to meet the market needs. That said, the leaders are technology neutral in that they view technology only as a means to meet customer and business needs. Therefore, they traditionally invested in the minimum technology to meet those needs and did not pursue excessive, dramatic technologies.

- Industry leaders strategically commit for the long haul – UPS spends over $1 billion annually to research and develop applications and technologies to supplement their information business. Purolator changed their entire approach to information services to meet customer needs. Industry leaders are making large investments in the information business as it adds increasingly more value to the customer.

- Customer-centric applications – As previously highlighted, industry leaders design applications with the customers' needs in mind and a pursuit to improve the quality of life for their customers. These applications provide the customer with a simple accessible means to accomplish their goals.

Technologies

Technologies are always changing, and more people are increasingly using them. In 2000, only 51 percent of households in the United States had a computer. However, by 2010, that number increased to 76.7 percent.[30] In 2001, dial-up Internet access was just as popular as broadband in the United States, but now 70 percent of people use broadband and only 3 percent of people use dial-up.[31] In 2011, more people opted for traditional cell phones over smartphones; today, 56 percent of people use smartphones and only 35 percent traditional cell phones.[32] These examples illustrate the lightning-quick pace at which today's technology moves. To embrace technology's creative chaos, the Postal Service needs to reevaluate technologies on a continuous basis.

How do these technologies work?

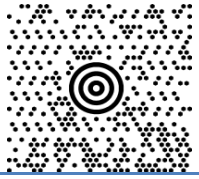
Mail tracking and scanning technology should be thought of as a means to gather data that can be transformed into information of interest to both a delivery service and its customers. Technologies can be used individually or in concert. In particular, technology recognizes individual items and assigns each one a unique identifier. This approach is called Auto-Identification and Data Capture (AIDC). AIDC technologies identify objects,

[30] U.S. Census Bureau, "Computer and Internet Use in the United States," May 2013, www.census.gov/prod/2013pubs/p20-569.pdf.
[31] "Trend Data," *Pew Research Center,* 2013, www.pewinternet.org/Trend-Data-(Adults)/Home-Broadband-Adoption.aspx.
[32] Aaron Smith, "Smartphone Ownership 2013," *Pew Research Center,* June 5, 2013, http://pewinternet.org/Reports/2013/Smartphone-Ownership-2013/Findings.aspx.

collect data about them, and allow that data to interact with computer systems. Commonly recognized AIDC technologies include Radio Frequency Identification (RFID), memory cards, magnetic strips, 1-D/2-D barcodes, biometrics, and GPS. The OIG worked with IBM to investigate and identify AIDC technologies that are potentially useful to the Postal Service.

Table 1 describes the technologies and presents sample applications and key features and Table 2 compares these technologies' attributes such as cost and effectiveness. Both tables present the most relevant mailing industry technologies — Appendix B presents a more comprehensive look at all tracking and scanning technologies researched.

Table 1: Tracking and Scanning Technologies Description

Technology	Sample Industries/ Applications	Key Features
1D Barcodes  	• Retail/ Grocery stores • Department of Defense • Healthcare	• Items can be quickly identified • Can be used on mail pieces and parcels for delivery/ tracking purposes
Matrix 2D Barcodes 	• Pharmaceuticals • Department of Defense at item level for high value assets • Packages at item level	• Items can be uniquely identified • Ability to store extra user information • Can be used on mail pieces and parcels for delivery/ tracking purposes
Passive RFID 	• Supply chain • Retail • Libraries • Inventory control	• Significantly lower tag cost than Active RFID • No internal power • Items can be uniquely and quickly identified • Industry Standard • Can be used on parcels and containers for delivery/ tracking purposes
Active RFID 	• Logistics • Supply chains • Shipping containers	• Battery powered • Input/output sensors/ capabilities • Long read distance • Can be used on parcels and containers for advanced delivery/ tracking purposes
Cellular/ Satellite based GPS 	• Logistics/ Container tracking • Fleet tracking • Agriculture equipment	• Visibility of assets during transportation without fixed infrastructure • Input/output sensors/ capabilities • Can be used on handheld mobile devices for delivery confirmation

Barcodes are the simplest technology in that they are merely a series of lines or symbols on a print medium. The major advantage of barcodes is their relatively low cost. The disadvantage is barcoding requires resources to manually or automatically scan one at a time with line of sight.

The Postal Service uses 1D barcodes, like the IMb, to track its products. This approach is inexpensive and reliant on scanners to read labels at specific scan points. UPS has used 1D barcodes in the past but now uses a special 2D barcode called a Maxicode.[33] UPS scans its barcodes in a manner similar to the Postal Service's, with a mix of automated and manual scan points.

Table 2: Tracking and Scanning Technologies Comparison Matrix

Technology	Readability/ Efficiency	In-Transit Visibility	Read Distance	Used in High Volume Applications	Maturity of Technology	Cost Trends	Current Cost
1D Barcode	◑	○	◔	●	●	→	$
Matrix 2D Barcode	◑	○	◔	◕	●	→	$
Passive RFID	●	○	◑	◕	◕	↓	$$
Active RFID	●	◔	◕	◔	◑	↓	$$$
Cellular/ Satellite based GPS	●	●	●	◔	◕	↓	$$$$

RFID are electronic tags read by local readers that either activate passive tags or receive signals from active tags. Passive tags are cheaper than active, because active tags contain a battery and additional capabilities. RFID technology is more versatile than barcodes because it can transmit more information and its readers can scan hundreds of tags at once, which is useful in labor-intensive industries when 100 percent scanning is required. The Postal Service has used active RFID for some internal equipment tracking and international mail performance tracking. The last Postal Service evaluation of passive RFID technology was in 2006.[34] Previously, passive RFID's costs were prohibitive to consider in lieu of barcodes, but it has become less expensive in the

[33] IBM interview with UPS.
[34] Interview with Information Technology department at Postal Service

last 5 years.[35] Russia's postal operator has recently indicated that in two years it will tag all its mail, up to 600 million items, with RFID.[36]

GPS' unique advantage is that a physical infrastructure (e.g., local readers) is not required to read the tag. A space-based satellite system captures the data. This permits the tag to communicate at virtually any time or any point in transit. Therefore, GPS is the most on-call, precise, and geographically unrestrained method of tracking available. The downside is that it is very expensive compared to RFID and barcodes. Each GPS tag can cost $150-$500. Placing GPS on all Postal Service vehicles could be expensive, but the value of the information provided might offset the cost. UPS uses GPS technology to track its local delivery trucks, measure stop time and mileage, monitor safety requirements, and improve and measure performance. Typically, a mix of technologies is most appropriate depending upon factors such as application, value of items being tracked, and level of visibility required.

"Technology is just a tool." – Bill Gates

Interestingly, upon examination of the available technologies and those used by the competitors, the Postal Service does not have a problem finding the right technology. The Postal Service has repeatedly researched and invested in the technologies for mail tracking; in fact, it uses the same comparative technology as its competitors. However, success may be less about the technologies and more about how the information is gathered and shared. The Postal Service has to refocus its efforts to determine what information is useful and how customers will use it.

Conclusion

In the age of information overload, it is ironic that the Postal Service could better serve the public by gathering and providing more information. In many areas, there is a clear demand for better information and applications such as mail tracking and tracing, package status, applications providing delivery options, and even areas like the weather or identity verification. Market needs for information are expanding and with the continuing emergence of handheld devices, analytics, cloud computing, and social media, information will only become more valuable.

[35] IBISWorld Industry Report 49222 - Couriers & Local Delivery Services in the US, March 2013, p. 30.
[36] Postal Technology International, March 2012, p. 48

Appendix A Applications for the Postal Service

The OIG collaborated with researchers from IBM to create this list of potential applications. The white paper highlights some of these applications. This list is not exhaustive, as other creative applications exist beyond this list.

Table 3: Sales Applications

Application Description	Strategic Consideration
Capture of 100% visibility and end-to-end tracking	Core requirement when competing for B2B volumes with UPS and FedEx; enabling technology to better optimize internal supply chain and reduce costs; key features for products in the Competitive Product portfolio; enhances the overall Postal Service brand image.
Ability to implement mid-shipment returns	Enhanced service offering will strengthen the overall value proposition for the Competitive Product portfolio and reduce operational costs to the Postal Service.
Delivery redirect	Enhanced service offering will provide new value added services utilizing track and trace information, reduce failed delivery attempts, reduce operational costs to the Postal Service, and enhance the overall value proposition in the Competitive Product portfolio.
Enhanced data services to large customers (en-route, accepted, delivered)	Accurate, real-time information will contribute to growth in B2B revenue and enhance the value of mail service offerings.
Enhanced tracking for high value items	Create new product offering to capture market share from competitors in this niche space; expand into new customer segment; enhance the overall value proposition for Competitive Product portfolio.
Up-sell services at the doorstep	Carrier utilizes mobile device to up-sell products and services such as carrier pickup, insurance, and delivery confirmation; can complete the transaction on the doorstep.
Mobile post office	Carrier utilizes mobile device to complete transactions at the doorstep, reducing need for individuals to visit brick and mortar post offices.
Guarantee package delivery	Standard track and trace information in addition to advanced information (damage, temperature, humidity, and barometric pressure) for high value shipments will equip mail service offerings with the ability to immediately notify when out of compliance events occur; enhanced value of service could increase revenue.
Secure government transactions	Combine track and trace data with existing applications such as Electronic Post Mark (EPM) to support new secure door-to-door government service interactions with citizens.
Revenue assurance	Capture of data allows not only for protecting customer revenues; also addresses scanning requirements per many bilateral agreements with Foreign Postal Administrations in chargeback revenue models.
Unbanked population transactions	Carriers could provide secure capabilities to the unbanked and underbanked for e-commerce payments that are not currently being provided.
Unknown future value add services	Best application utilizing track and trace information might not have yet been invented that enhance the overall value of the mail.

Table 4: Transportation Applications

Application Description	Strategic Consideration
Keyless RFID entry system to delivery trucks	Passive technologies would allow drivers to automatically enter and start their delivery vehicles; this process would increase the safety for workers and the security of the contents of delivery vehicles and would also reduce the potential need for costly locksmith/ lock changes.
Reduced truck check-in time at facilities	Passively tagged trucks would streamline the check-in process when arriving at facilities.
Improve asset maintenance and record keeping	Information passively collected via RFID would better enable tracking events such as tire rotation, replacement, alignment, etc., as well as immediate, on-line access to logs of previous maintenance work.
Improve preventative maintenance	Information passively collected and stored via RFID would allow for more accurate coordination of preventative maintenance for assets whether based on mileage, motor runtimes, or a combination of both.
Predict and pre-notify maintenance events for assets	Information passively collected and stored via RFID would better predict when maintenance measures will need to be completed as opposed to simply responding to malfunctions as they occur.
Improve inventory control of spare trailer parts	Passive RFID technology would allow for more automated inventory control and procurement of spare parts for trucks.
Truck visibility within trailer yard	RFID-equipped trailers would be easier to locate and monitor within RFID-equipped zones, knowing accurately and in real-time, which vehicles are in the trailer yard, which are at loading docks, and which are off-premises.
Reduce detention and demurrage charges	RFID real-time alerts would reduce detention and demurrage penalties associated with trailer yard delays by alerting users of status by trailer.
Traffic flow information	Carriers can use GPS-equipped mobile devices to report on traffic conditions to reroute shipments, to reduce cost, and as a public service.
Manage HCR transportation lanes	More granular tracking data will assist in optimizing HCR lanes and aid in negotiating new HCR contracts.
Fuel usage	More granular tracking data can help ensure adherence to scheduled routes and save on fuel costs.
Trailer arrivals at facilities	More granular tracking data will help better schedule trailer arrivals at facilities to reduce the time spent idling and save on fuel costs.
Weather information	Carriers can use GPS-equipped mobile devices to report on weather conditions as a public service.
Map information	Carriers can use GPS-equipped mobile devices to report on road map accuracy, especially in areas under construction and new housing developments and addresses.
Address quality	Carriers can use GPS-equipped mobile devices to report on accuracy of new addresses and identify locations for cluster boxes in new developments.
Parcel/ Mail to meet service	Passive RFID technology can automatically identify how long mail and parcels have been idle and send notifications if appropriate.
Parcel/ Mail in appropriate truck	Passive RFID technology will reduce loading errors by helping ensure that mail and parcels get loaded into the appropriate truck.

Table 5: En-Route Operations Applications

Application Description	Strategic Consideration
Better determine staffing requirements	Accurate, real-time track and trace information can aid in determining staffing requirements to fill orders and create staffing plans both for in-plant operations and scheduled delivery.
Improve call center effectiveness	Better track and trace information can provide call centers employees with more real-time information to assist customer inquiries. This reduces overall call time and increases worker efficiency.
Identify mail at risk of missing service	Accurate, real-time information (along with passive RFID) will help identify and correct en-route issues to enhance the overall value proposition of using the mail.
Improve service performance	Accurate, real-time information will provide diagnostic tools with better data to improve the overall operation of the supply chain.
Better visibility into supply chain	Accurate, real-time information will help users to utilize diagnostic tools to reduce overall costs in the supply chain.
Improve inventory control	Passive tracking technology such as RFID would allow for more automated inventory control and procurement of spare parts for trucks; physical inventories will be performed with better accuracy and significantly faster.
Reduce asset loss	Tagging MTE with passive tracking technology would reduce the significant yearly loss in MTE.

Table 6: Customer Service / CRM Applications

Application Description	Strategic Consideration
Increased delivery schedule flexibility	Access to accurate, real-time tracking data would allow for better delivery scheduling flexibility and also enhances the value proposition of the Competitive Products portfolio; offers the opportunity to increase revenues and enhances the overall Postal Service brand image.
Reduced reliance on call centers as main CRM touch point	Accurate, real-time customer service applications allow for better shipment visibility for customers, which would reduce the number of tracking inquiries to customer call centers.
Automate generation of customer invoices	Access to accurate, real-time information will streamline interactions with customers, result in fewer calls with customers, and reduce cost.
Customs data clearance	Sharing of accurate, real-time shipment information would enhance cross-border shipment security, which might expand international trade markets.

Table 7: Delivery / Delivery Network / Last Mile Applications

Application Description	Strategic Consideration
Monitor delivery truck's rear door	Sensors can detect open doors or unsecure latches. Help ensure mail integrity and general delivery safety and security.
Monitor delivery truck compliance on scheduled route	Accurate, real-time information will help plan and manage delivery routes, immediately report out-of-compliance activities, better predict delivery times, increase scheduling and staffing efficiency, and reduce costs.
Optimize dynamic delivery routes	Enables same day delivery, five-day delivery, Saturday and/ or Sunday parcel delivery, and the development of newer more day-certain and day-specific delivery services.

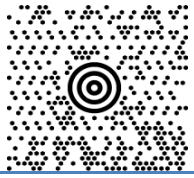
Table 8: Safety / Security Applications

Application Description	Strategic Consideration
Mail theft	Ability to identify and resolve issues in near-real time enhances the overall value proposition of the Competitive Product portfolio; passive tracking technology might further reduce overall incidents of lost mail.
Monitor driver seatbelt use	Sensors can monitor the use of a seatbelt and also the speed of the vehicle to detect vehicle motion without the use of a seatbelt. Reduce injury rate and OWCP costs.
Monitor delivery truck's side door	Sensors can monitor open doors like a driver or passenger door. Reduce injury rate and OWCP costs.
Monitor aggressive driving	Reduce incident rate by real time tracking of delivery trucks.
Monitor speeding	Reduce incident rate by real time tracking of delivery trucks.
Emergency messaging	Ability to simultaneously contact all drivers via message to their mobile device to alert them of an emergency (such as 9/11), and how to respond.
Report emergency events	Carriers can use mobile devices to capture and report emergency information such as power outages, downed power lines and trees, non-functioning traffic lights, etc.; can also serve as a public service after weather events, terrorist attacks, etc.
Personnel Emergency Response	In the event of a disaster or emergency, identify the location of personnel via GPS.
Report infrastructure damage and issues	Carriers can use mobile devices to capture and report information in neighborhoods such as potholes, damaged traffic signs, etc. as a public service such as the 'SeeClickFix' application in Richmond, Va.
Citizen Services	Carriers can utilize mobile devices to check-in and report on medical status of elderly citizens, specifically in rural areas (currently being explored in France in the countryside).
Intercept mail threat	Identify where a mail piece is in the supply chain that presents a threat (crime, biohazard, investigation, imminent danger).

Appendix B Technology Research

This paper highlights the tracking technologies most relevant to the postal industry; however, this appendix describes and compares a broader range of technologies and includes active real-time location system (RTLS), ZigBee, and Bluetooth (BLE) technologies. Active RTLS are wireless, usually radio frequency driven, tags that can be attached to an object to track its path through local facilities, such as warehouses, hospitals, or assembly lines. ZigBee is a newer specification, wireless transmitter capable of communicating up to 100 meters. Bluetooth uses short-wavelength radio transmissions to communicate over short distances. It can connect several devices overcoming conflict and synchronization issues.

Table 9: Description of Technologies — All Researched Technologies

Technology	Sample Industries/ Applications	Key Features
1-D Barcodes 	• Retail/ Grocery Stores • Department of Defense • Healthcare	• Items can be quickly identified • Can be used on mail pieces and parcels for delivery/ tracking purposes • Can be used in a distribution facility on containers
Matrix 2-D Barcodes 	• Pharmaceuticals • Department of Defense at item level for high value assets • Packages at item level	• Items can be uniquely identified • Ability to store extra user information • Can be used on mail pieces and parcels for delivery/ tracking purposes • Can be used in a distribution facility on containers
Passive RFID 	• Supply Chain • Retail • Libraries • Inventory Control	• Significantly lower tag cost than Active RFID • No internal power • Items can be uniquely and quickly identified • Industry Standard • Can be used on parcels and containers for delivery/ tracking purposes • Can be used on trucks in the yard for tracking and inventory purposes
Active RFID 	• Logistics • Supply Chains • Shipping containers	• Battery powered • Input/output sensors/ capabilities • Long read distance • Can be used on parcels and containers for advanced delivery/ tracking purposes
Active RTLS 	• Healthcare • Industrial • Yard Management	• Battery powered • Input/ output sensors/ capabilities • Provides near real-time location in X,Y coordinates • Can be used on parcels for delivery/ tracking; limited application to the postal industry

Technology	Sample Industries/ Applications	Key Features
ZigBee 	• Home Entertainment and Control • Building Automation • Traffic Management Systems	• Secure networking • Low data rate • Long battery life* • Can be used in a distribution facility on containers
Cellular/ Satellite based GPS 	• Logistics/ Container tracking • Fleet tracking • Agriculture Equipment	• Visibility of assets during transportation without fixed infrastructure • Input/output sensors/ capabilities • Can be used on handheld mobile devices for delivery confirmation
BLE 	• Health and Wellness • Sport and Fitness	• Low power requirements • Small size • Compatibility with a large installed base of mobile phones, tablets and computers†

* "FAQ," Zigbee *Alliance,* 2013, http://www.zigbee.org/About/FAQ.aspx.

† "Low Energy," *Bluetooth,* 2013, www.bluetooth.com.

Table 10: Technology Comparison Matrix — All Researched Technologies

Technology	Readability/ Efficiency	In-Transit Visibility	Read Distance	Used in High Volume Applications	Maturity of Technology	Cost Trends	Current Cost
1-D Barcode	◑	○	◔	●	●	→	$
Data Matrix/2-D Barcode	◑	○	◔	◕	●	→	$
Passive UHF RFID	●	○	◔	◕	◕	↓	$$
Active RFID	●	◔	◕	◔	◑	↓	$$$
Active RTLS	●	◑	◑	◔	◑	↓	$$$
ZigBee	●	◑	◑	◑	◕	↓	$$$
GPS	●	●	●	◔	◕	↓	$$$$
BLE	◑	○	◑	◔	◔	→	N/A

Table 11: Technology Matrix Breakdown — 1-D Barcode

Criteria	Rating	Comments
Readability/ Efficiency		Ability to read one barcode at a time via line of sight technology.
In-transit Visibility		Does not provide in-transit visibility. Barcodes may only be read by handheld devices while in transit.
Read Distance		Typically less than 6" with a "scanning gun."*
Used in High Volume Applications		Yes — used in virtually all industries.
Maturity of Technology		Very mature — in the 1970's bar coding was introduced to grocery store applications and was adapted by the DoD in the early 1980s.†
Cost Trends		Very low cost — ink for barcodes is a lot cheaper than RFID tags. The proliferation of barcodes, along with the availability of equipment has made barcodes affordable. Many smart phones now include apps to read barcodes. Barcode technology has likely reached a price floor.
Current Cost		Pennies or less per barcode

* Barcode Scanning Overview," *POSWorld,* http://www.posworld.com/barcodbas.html.

† "Grocery Store Applications in the 1970s," *Fortune Magazine*, 2004, http://money.cnn.com/magazines/fortune/fortune_archive/2004/05/31/370719/index.htm, and Hiroko Kato, Keng T. Tan, and Douglas Chai, *Barcodes for Mobile Devices*, (Cambridge: Cambridge University Press, 2010) p. 223.

Table 12: Technology Matrix Breakdown — 2-D Barcode

Criteria	Rating	Comments
Readability/ Efficiency		Ability to read one barcode at a time via line of sight technology.
In-transit Visibility		Does not provide in-transit visibility. Barcodes may only be read by handheld devices.
Read Distance		Depends upon the size of the barcode, but generally speaking, it is read over a very short distance.
Used in High Volume Applications		Yes — especially with higher value/ counterfeit items. However, not used as widely as 1D barcodes.
Maturity of Technology		Very mature.
Cost Trends		Very low cost for barcode — ink for barcodes is a lot cheaper than RFID tags. Similar to 1-D barcodes, the cost for 2-D barcodes remains very cheap in comparison to other technologies. Smart phone apps also have the capability to read 2-D/Matrix barcodes.*
Current Cost		Pennies per barcode.

* "How UPC Bar Codes Work," *HowStuffWorks,* September 13, 2013.

Table 13: Technology Matrix Breakdown — Passive RFID

Criteria	Rating	Comments
Readability/ Efficiency		Ability to read multiple (hundreds) of tags within seconds and line-of-sight is NOT required. Tags are required to be within the read zones.
In-transit Visibility		Does not provide in-transit visibility. Tags may only be read by RFID enable handheld devices or when the tag goes through a fixed reader "portal"/ chokepoint.
Read Distance		Passive RFID typically has a read range from 1- 60 feet, depending upon the form factor, IC chip, antenna, reader, interference, etc. In many standard use cases with fixed RFID readers, the read distances are configured to approximately 10-25 feet.*
Used in High Volume Applications		Yes — Used in supply chain applications and across the retail industries. However, it is not nearly as accepted as bar coding technology.
Maturity of Technology		UHF passive RFID has a ratified standard and the technology works reliably with the appropriate set-up/ configuration.
Cost Trends		Costs of tags and readers have significantly decreased in cost over the last 10 years. As the number of passive RFID tags used by companies increases, particularly in asset tracking and inventory control, the price continues to decline.†
Current Cost		$0.10 per UHF tag for high volume, all-purpose tags that are not pre-programmed. Fixed UHF readers have also significantly decreased in cost (e.g. less than $1,000/ fixed reader).

* "Active Vs. Passive RFID," *AtlasRFID Solutions,* 2013, http://www.atlasrfid.com/auto-id-education/active-vs-passive-rfid/.

† "U.S. Manufacturers Report Greater RFID Usage," *RFID Journal,* September 19, 2013.

Table 14: Technology Matrix Breakdown — Active RFID

Criteria	Rating	Comments
Readability/ Efficiency		Ability to read multiple (hundreds) of tags within seconds and line-of-sight is NOT required. Tags are required to be within the read zones.
In-transit Visibility		Does not provide in-transit visibility. Tags may only be read by RFID when the tag goes through a fixed reader "portal"/ chokepoint, but the tag read ranges may be very long.*
Read Distance		Varies; typically the distance ranges from 500- 1,600+ ft.
Used in High Volume Applications		Typically used to track container level assets.
Maturity of Technology		The technology has been used throughout the DoD to track shipments/ containers. However, there is not a ratified global standard to make tags/ readers interoperable. ISO/IEC 18000-7:2009 exists and defines the air interface for radio frequency identification (RFID) devices operating as an active RF tag in the 433 MHz band used in item management applications.
Cost Trends		Costs of tags and readers have decreased over the last 10 years. There has been an increase in manufacturers requiring suppliers to provide RFID tagged materials in order to facilitate the tracking of inventory. RFID systems are also projected to increase in popularity. This increase in utilization correlates with decreased costs, making the product more cost-justifiable.†
Current Cost		$20-$80 per tag.

* "Active Vs. Passive RFID," *AtlasRFID.*

† U.S. Manufacturers Report Greater RFID Usage," *RFID Journal.*

Table 15: Technology Matrix Breakdown — Active RTLS

Criteria	Rating	Comments
Readability/ Efficiency		Ability to read multiple (hundreds/ thousands) of tags within seconds and line-of-sight is NOT required. Tags are required to be within the coverage range.
In-transit Visibility		Near-real time in-transit visibility/ accuracy is provided when a tag is within the coverage range (e.g. indoor building).
Read Distance		Read distance various depending upon the environment (e.g. indoor/ outdoor), infrastructure, etc. A typical indoor read range may be 180 ft. depending upon the tag and environment. Line of sight is not required.
Used in High Volume Applications		Typically used to track high-value assets and/ or resources.
Maturity of Technology		The technology has become more popular throughout the healthcare and industrial industries to track high dollar value assets and to help improve employee safety. However, there is not a ratified global standard to make tags/ readers interoperable.
Cost Trends		Costs of tags and infrastructure (optional) have decreased in cost over the last 10 years. Similar to active RFID, the ability of RTLS to offer real time information is very appealing to many markets. However, many companies, while aware of RFID, may still be unaware of RTLS technology. This factor may be key in its success in driving the market, and increasing RTLS adoption and decreasing costs. Currently, RTLS costs have been decreasing at a rate of 5 to 20 percent annually.[*]
Current Cost		$30-$80 per active tag.

[*] "RTLS Market Overview." *RTLS Market Overview*. September 10, 2013, www.RFID.net.

Table 16: Technology Matrix Breakdown — ZigBee

Criteria	Rating	Comments
Readability/ Efficiency		Designed for hostile RF environments that exist in commercial applications. ZigBee can transmit data over long distances by passing it through intermediary devices.
In-transit Visibility		The device must be within the mesh network to be read.
Read Distance		Range of 32-328 ft. As long as a wireless network exists across the mesh, a connection can be made. An "end device" can relay data to the "coordinator device" or a "router device." Only one coordinator device exists in each network.
Used in High Volume Applications		A typical network can hold 64,000 nodes/ network. Multiple networks can be linked together in order to support an extremely large network. A node can wake up, check in, send data, and shut down in less than 30 minutes.
Maturity of Technology		The technology was conceived in 1998, standardized in 2003, and revised in 2006. The standard is IEEE 802.15.4, which is the standard for low-rate wireless personal area networks. To utilize ZigBee for commercial use, you must be a part of the ZigBee Alliance.[*]
Cost Trends		Must establish a ZigBee network, however it is designed to be less expensive than Bluetooth. The prices of Zigbee are decreasing. Because wireless infrastructure prices continue to decease, this directly relates to the cost decline associated with this technology. Low power usage and long battery life make this product relatively inexpensive.[†]
Current Cost		$30-$70 per tag.

[*] "FAQ," Zigbee *Alliance.*

[†] "ZigBee® Wireless Standard - Technology - Digi International," *ZigBee® Wireless Standard - Technology - Digi International,* September 20, 2013.

Table 17: Technology Matrix Breakdown — Cellular / Satellite based GPS

Criteria	Rating	Comments
Readability/ Efficiency	●	Satellite based GPS operates anywhere in the world. Cellular based GPS operates within cellular coverage areas.
In-transit Visibility	●	In-transit visibility is fully supported.
Read Distance	●	Satellite based GPS operates anywhere in the world. Cellular based GPS operates within cellular coverage areas.
Used in High Volume Applications	◔	Typically used at the vehicle level and with high dollar/ strategic equipment.
Maturity of Technology	◕	Technology has been widely used in consumer and business applications (e.g. DoD tracking of containers in-theater).
Cost Trends	↓	Decreasing over time and has become more widely used in consumer and business applications. Because of the decreasing costs of GPS receivers, the general public is increasing its use of GPS technology. More recently, personal navigations systems enabled with GPS technology have taken price cuts up to 40 percent.*
Current Cost	○	$150-$500 per tag.

* "Illumin - The Evolution of GPS," *Illumin - The Evolution of GPS,* University of Southern California, September 19, 2013.

Table 18: Technology Matrix Breakdown — BLE

Criteria	Rating	Comments
Readability/ Efficiency	◑	Even greater than classic Bluetooth technology, BLE over the air data rate is 1Mbit/s.
In-transit Visibility	◔	Works over wireless connectivity within a close physical range.
Read Distance	◑	50m (160 ft).
Used in High Volume Applications	◔	Not particularly equipped to handle large/ expansive applications. BLE also has a 32-bit Message Integrity Check System.
Maturity of Technology	◔	BLE, originally introduced by Nokia, but merged into the Bluetooth standard in 2010. Most recently Apple has become the first major operating system to support BLE. Manufactures and application developers can differentiate themselves by building BLE compatible devices.*
Cost Trends	→	Manufacturers are expected to implement appropriate specifications for their device to ensure compatibility. Cost depends on the type of technology chosen (e.g. BLE enabled phone). However, it markets itself as low cost and operates on low power wireless connectivity.†
Current Cost	N/A	N/A

* "Low Energy," *Bluetooth.*

† Ibid.

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