1-D Barcode

A 1-D barcode is a small series of stripes (parallel lines) varying in width and spacing used to represent data. This barcode can be scanned optically by a machine to withdraw the data enclosed. The most common barcode that can be found on grocery items and retail items all over the world is the Universal Product Code (UPC). Second in popularity is the International Article Number (EAN), called the JAN in Japan. All of these variations of 1-D barcodes are housed under the umbrella of Global Trade Item Numbers (GTIN). They UPC is the most widely used, the EAN is smaller (8 digits instead of 12-14) and therefore better for smaller items. In order to get a barcode on an item, one must go through the GS1, a non-profit international organization that works with trading partners, industries, governments, and technology providers across multiple sectors. Standards must be developed for identification or items, capture of items, and the way the data is shared.

When they first originated, special machines were needed to scan them but today they can be read by printers and a wide variety of other electronic devices. For application in an airport / travel environment, smartphones and tablets have the capability to use their cameras to scan a 1-D barcode. Smartphones can be used to either display the barcode, or scan a barcode to elicit information. For the latter, a third party application may be required depending on the model of phone.

Current Leading Vendors: Intermec, DESKO

Airport / Airline Examples:

- Virtually every airline and airport uses 1-D barcodes on printed boarding passes, including home-printed ones, and each gate is equipped with an optical scanner used during boarding.
- 1-D barcodes can also be scanned by check-in kiosks where the boarding pass is used for check-in.
- 1-D barcodes are used on food and beverage items sold during in-Flight. Virtually every airline allows credit card purchases which require special readers, including a scanner to scan the barcodes

2-D Barcode

2-D barcodes are geometric patterns in two dimensions that use hexagons, rectangles, and other shapes to represent data. Like their 1-D predecessor, they are also read by machines. A popular and widespread example of a 2-D barcode is the Quick Response (QR) code, a small square made up of other squares patterned differently. These can be used in advertising, such as on billboards or brochures handed out by concessionaires, and for identification of an individual. Both are widely used at virtually all airports by all airlines, especially in form of boarding passes and bag tags, either on a printed document or electronically on smartphones or smartwatches. Exactly as with the 1-D barcode, it is necessary for the 2-D barcode to be printed or shown on a surface to be able to be optically scanned and have the data extracted.

In addition to the more popular QR code, some mobile boarding passes use Aztec code and Datamatrix for smartphone scanning. Throughout the airport, inside and out of security, 2-D barcodes (prominently QR codes) are incredibly popular and capable of the most diverse functions as once scanned they can interact with other applications on a user's mobile device.

Current Leading Vendors: Intermec, DESKO

Airport / Airline Examples:

- On its Frankfurt – Tokyo Narita route, Lufthansa provides an RFID-enabled bag tag sleeve for home–printed bag tags. Attached to the passenger's luggage, this sleeve also includes a home-printed boarding pass in form barcodes. The luggage can then be dropped off at any of the airlines self-service bag drop kiosks at either airport. The tag also includes an additional QR code, therefore travel details can be reconstructed if the tag has been damaged.
- Phoenix Sky Harbor International Airport uses QR codes throughout the entire airport in an effort to make navigation as easy as possible for passengers.
- Sydney, Melbourne and Brisbane airports in Australia offer 39 digital screens from Google that use NFC and QR codes to connect to the Google Play store and allow the user to purchase movies, music, and books and download them immediately for enjoyment during flights.
- Indianapolis International Airport has QR codes throughout their parking shelters to help people find their parking spaces.

Augmented Reality (AR)

Augmented reality (AR) refers to a real-time view of a physical location whose elements are amplified by GPS data, video, graphics, or audio sensory input generated by a computer. The intended use of AR is to sharpen the reality an individual perceives and experience. While virtual reality simulates a world, augmented reality enhances the real world concurrently and contextually utilizing components of the environment, like up-to-date flight information including delays. Advanced AR has the potential to integrate digital information into the environment of the user, allowing for direct interaction by the user. The artificial data about each environment and the objects within are able to be superimposed into the real world. Using the camera the user can scan their environment and the AR reveals points of interest including gates and deliver information about distance and direction to those points.

Marketing has traditionally been the number one use of AR. Several businesses have created applications for mobile devices that allow users to interact with their environment. Magazines and other forms of online print are also attempting to utilize AR. The auto industry also delved into possible AR use by using a 4D display at several auto shows.

Since AR is such a young technology, there is reluctance for mass adoption. Many critics claim that, while impressive, it will not gain traction and is more of an interesting idea than an applicable solution.

Current Leading Vendors: SITA Lab, Novasa

Airport / Airline Examples:

- Copenhagen International Airport (CPH) engaged SITA Lab and Novasa to upgrade its existing airport mobile app with an augmented reality technology feature based on WiFi triangulation accurate to a few meters using existing access points. By "scanning" their immediate surroundings with the phone's camera, passengers are shown locations and distances to concessionaires, information restaurants, and gates.
- Japan Airlines developed mobile apps for iOS and Android devices that allow passengers to explore terminal buildings in 3-D augmented reality, view live video feeds from airports including live security queue lines, and access details on local weather and events.

Beam Counters

Beam counter systems emit an infrared beam from a compact electronic device to an opposing receiver. The system registers each beam disruption as a passenger count and sends data either through a wireless link or cellular network. Some systems have about a 20 foot range compared to standalone versions that range only about 8 feet. This is a fairly accurate technology, with vertical beams being more accurate than horizontal beams. Beam counters are easily deployable solutions to give insight into queue lines and can help an airport identify areas of improvement in relation to peak passenger travel times and patterns.

Some drawbacks to this type of passenger counting include the fact that they are incapable of intuiting direction, unable to measure high volume traffic, cannot avoid being blocked by either people or objects, and easily damaged by direct sunlight. The trend in airports is to use a more than one passenger counting technology to develop a passenger counting system most useful to the airport in meeting the its unique needs based on its unique profile.

Current Leading Vendors: Qmetrix, Irisys, Axiomatic

Airport / Airline Examples:

- East Midlands Airport in the UK uses Axiomatic People Counting beam counters to measure footfall data and passenger flow as well as queue times.
- Many airports use beam counters in their security lines as they easily register when one person passes through the beam going in one direction. .

Bluetooth Low Energy (BLE)

BLE (Bluetooth Low Energy or Bluetooth Smart) is a wireless, personal area network designed and marketed by Bluetooth's Special Interest Group. It has been applied in the healthcare, home entertainment, and fitness industries, however, it is quickly becoming popular in the transportation industry with the breakout of its applicability in Indoor Positioning. BLE consumes a significantly less amount of power while maintaining almost an equal range. Mobile operating systems, such as iOS, Android, Windows 8, Linux, and Blackberry, inherently support BLE. Exactly as with Bluetooth, BLE devices must meet SIG's standards and maintain specifications to ensure compatibility. It uses the same 2.4 GHz radio frequency but employs a simpler system of modulation. While Bluetooth was slowly beginning to fade in the technological landscape, the introduction and application of BLE brought back its popularity, as functional applications have improved.

In the airport environment, BLE is used in sensors such as iBeacons and Gimbal (hundreds throughout an airport) to offer positioning, tracking, advertising, baggage tracking, and others.

Current Leading Vendors: Apple, Qualcomm, Google, Motorola

Airport / Airline Examples:

- Miami International Airport was the first in the world to deploy beacons powered by BLE, available to all stakeholders via the SITA Common-Use Beacon Registry.
- easyJet has trialed an iBeacon deployment within London's Luton Airport, Gatwick Airport, and Paris Charles de Gaulle Airport.
- Virgin Atlantic is currently deploying iBeacons at London's Heathrow Airport.
- American Airlines is trailing iBeacons in five U.S. airports at the time of this writing.
- Gimbal by Qualcomm is relatively new at the time of this writing and is predicted to become a strong player in the BLE market for airports.

2-D Barcode

Bluetooth is a wireless technology standard used to transfer data (including voice, data, music, photos, videos, etc) over short distances by utilizing short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz. It can connect several fixed and mobile devices which defeats the complications of synchronization. The Bluetooth Special Interest Group (SIG) currently manages Bluetooth and consists of more than 20,000 member companies that range across the following industries: telecommunication, networking, consumer electronics, and computing. To meet the requirements and be sold as a Bluetooth device, the device must meet the SIG standards and the inventor of the device must acquire a network of patents licensed only for that qualifying device.

Connecting devices require a small computer chip containing the Bluetooth radio as well as software to connect, via Bluetooth technology. Connected devices do not have to maintain a line of sight because they use a radio communications system. Typically, Bluetooth applications are utilized indoors within a single room or limited space. Maximum and minimum range requirements per device are set based on specific use cases. Factors that affect range are material coverage, production variations, battery conditions, and how antennae are configured. This technology has been applied in many industries. A myriad of devices use Bluetooth technology, however, some of the more common examples include smartphones, computers, and in-dash GPS in cars.

Popular in the airport and aviation sector is a subset of Bluetooth that operates with less power, BLE, and offers somewhat different functionalities.

Current Leading Vendors: Google, Qualcomm, Motorola, ChromaACDB

Airport / Airline Examples:

- Both George Bush Intercontinental and William P. Hobby airports in Houston have a Bluetooth-based, real-time queue measurement system implemented.
- Copenhagen International Airport in Geneva has used Bluetooth in the past for passenger tracking.
- Italy's Milan Malpensa and Linate airports were the first in Italy to install Bluetooth queue-management software using The Amor Group's ChromaACDB.

Close Proximity Systems

Close proximity systems primarily use sensors that can be used to transmit and receive data. These small sensors, sometime called beacons, are a cost effective way to transfer data. They generally use Bluetooth Low Energy (BLE) technology to transmit information between them and a receiver, such as a smartphone or similar device. Indoor navigation, passenger tracking, social media, and advertising/ promotion all have potential to be successful applications of this kind of technology. Bluetooth, while a great solution for determining proximity, is unable to pinpoint an exact location.

Researchers estimate that these types of sensors will be much more common in many environments, including airports. In the case of the iBeacon, there are 3 distinct ranges: immediate (within a few centimeters), near (within a couple of meters) and far (greater than 10 meters away). The user is presented different options depending on their distance from the beacon. A limiting factor can be, however, to what extent passengers perceive this to be an invasion of privacy, since related services – such as push-notifications – are based on a person's private data, including flight information and shopping or food/beverage preferences. Opt-in passenger programs have proven to be a good way to mediate this potential issue. Another limiting factor is the drain that these sensors have on a user's smartphone if enabled. Studies have shown that older phones (2011-2012) suffer as much as 11% more of battery drain when in contact with active sensors. A solution that is easier on the battery usage would solve this problem and is being developed in late 2014.

Current Leading Vendors: Apple (iBeacon), Qualcomm (Gimbal proximity beacons)

Airport / Airline Examples:

- easyJet trialed iBeacon technology pilots at London Luton, London Gatwick, and Paris Charles de Gaulle airports. Initial application was at bag drop and security touch points and provided push-notification via a required smartphone app to remind passengers of needed documentation.
- American Airlines at Dallas/Fort Worth International Airport has trialed the SITA Common-use Beacon Registry. The installation of iBeacons, which use BLE and geofencing, is utilized to improve wayfinding in the terminal, as well as show walking times to gates, provide lounge access, and inform passengers in real-time of boarding updates.
- Miami International Airport has deployed SITA's Common-Use Beacon Registry to make iBeacons (available to all of the airport's stakeholders) which cover entrances, check-in, gate, baggage claim, and valet parking zones across the airport.
- At Copenhagen Airport, sensor-based predictive modeling is used to measure the passenger flow and waiting times. This enables the airport to efficiently allocate staff and optimize terminal space.
- Finavia Airport tracks passengers via their smartphones from the car park to the departure gate, as to manage queues and to create commercial opportunities enabling the airport to interact with passengers based on their current location during their journey.

Context-Aware Mobile Applications (CMA)

Context Awareness (CA) is a broad term that encompasses many industries with regard to computing, linking changes in location and environment to the user. In this sense, many companies have developed Context-Aware Mobile Computing which is used to notice and respond to what is actively occurring in a user's environment based on specific user information stored in a mobile application.

CA in mobile computing has been theorized for over 15 years and only beginning in 2008/9 has mobile technology caught up to the theoretical application. An amalgamation of limiting factors exist as it can be quite difficult to find out the "who", "where", and "when" of a user when so many humans do not fully disclose information about themselves, fail to update their calendar, and push things back in their schedule without actually going into the application and changing the time. Another aspect that hinders adaptation of CA is security and privacy. This technology requires much personal information, which is often only reluctantly disclosed, therefore there is a strong need for security to protect that information. This has been a challenge to overcome.

Current Leading Vendors: SITA, Qualcomm

Airport / Airline Examples:

- Malaysia Airlines has a context-aware mobile application called flymas.mobi developed by SITA Lab that allows passengers to use their mobile devices (all major operating systems and manufacturers) to book travel, pay for travel, check in, and board. Also they can track their baggage and connect to social media all in one place.
- Copenhagen International Airport is using iBeacons in conjunction with a variety of other technologies with context-awareness developed by SITA Lab to automatically launch the airport's application on a user's phone when the user comes in close proximity of the airport.

Facial Recognition

Facial recognition is a biometric method which deals with a comprehensive 3D scan of a person's face. It is a very accurate method using factors such as textures of skin and being able to incorporate algorithms to determine eye width and all other dimensions. Several cameras take captures of an individual's face; these pictures are then compared to a database. This technology has been used by governments worldwide for a number of years and it becomes more and more precise a science as it continues to develop. Many examples of facial recognition are found in the criminal justice system to identify perpetrators of crimes with just a video or camera shot.

For identification purposes, facial recognition is a relatively non-invasive solution. Passengers walking through the various airport areas are constantly being monitored by a multitude of installed video cameras. Whether one day everyone can pass through security simply by getting their picture taken I sto be seen, but certain airport and airlines are considering it. It certainly is an effective means of determining identity. This form of biometrics is the perfect example of something that can be complementary to another biometric method. Since faces can change due to age, injury, or plastic surgery, a facial scan is not always 100% accurate. When paired with a fingerprint it can be quite successful and easy to deploy and maintain.

Current Leading Vendors: Human Recognition Systems (HRS), Artec Group, Aurora

Airport / Airline Examples:

- Hamad International Airport in Doha installed 62 automated border control e-gates (vb i-match eGates supplied by Vision-Box). They are tailored specifically to the requirements of the Airport, and make use of face, iris, and fingerprint recognition technology to ensure the highest possible level of accuracy and border security and to support the airport's vision to create a seamless travel experience.
- Major Australian airports will be using SmartGates, utilizing facial recognition, beginning in 2015, to automate the outbound customs process for passengers.
- Gatwick Airport and Human Recognition Systems (HRS) provide an end-to-end biometric solution (MFlow – using iris and facial recognition) to validate passengers at all stages of the process and to manage passengers across a series of identity points – from car parking to ticket production to purchasing a discounted product in the retail space. It enables Gatwick to automate passenger identification, enhance its overall passenger experience, and grow the airport's non-aeronautical revenue.

Finger Printing

One of the earliest and most widely adopted forms of biometrics is fingerprint scanning to verify identity. Not only is fingerprint scanning the easiest and most traditional biometrics, it is also considered the most reliable. Facial recognition, iris scanning, and even voice analysis can change as a user ages; while fingerprints endure. The base model of fingerprint scanner has two parts: the sensor, which scans the ridges and maps the fingerprint, and the processor which uses software to access a database of fingerprints to compare and ultimately identify the user. Applications are seen in government buildings, airports, schools, offices, and even dentist offices. Smartphones have begun to use finger-printing functionality to control unwanted access if a phone has been lost or stolen

There are a myriad of available vendors offering units of all dimensions, weights, and prices. Many airports have opted to implement some kind of fingerprinting application as it saves quite a bit of time in queue lines as opposed to scanning a passport and having to review information manually.

Current Leading Vendors: Morpho, 3M Cogent, BIO-key, MorphoTrak, NEC, Zwipe, Lumidigm

Airport / Airline Examples:

- Hamad International Airport in Doha installed 62 automated border control e-gates (vb i-match eGates supplied by Vision-Box). They are tailored specifically to the requirements of the Airport, and make use of face, iris, and fingerprint recognition technology to ensure the highest possible level of accuracy and border security and to support the airport's vision to create a seamless travel experience.
- Various major U.S. airports deploy the finger-printing based Global Entry program; others such as Dallas/Fort Worth, Denver Airport, and San Francisco Airport implemented the biometric-based CLEARcard. Passengers present the card at a kiosk where their identities are biometrically verified and then proceed through the designated fast lane.
- Little Rock National Airport needed to protect restricted areas from unauthorized personnel. It deployed a combined smart card reader/biometric fingerprint reader solution to ensure extremely tight control of movement within the facility and eliminate unauthorized entry.

Global Positioning System (GPS)

GPS is a satellite-based navigation system that can pinpoint the location of a compatible receiver, such as smartphone, or tablet. Basic GPS can provide only a location, but most GPS units routinely derive which direction a receiver is moving as well as its speed. Change in speed or direction may cause the direction to become somewhat inaccurate. A compass or inertial navigation system is used frequently in addition to GPS to get a more accurate position.

GPS is based in space and can provide information about location and time anywhere on or near our planet where there is a clear line of sight to four or more GPS satellites. The United States government maintains the GPS and it is freely accessible to anyone with a compatible receiver. Other countries, including India, China and Russia, have been working to create a similar system of satellites to improve navigation.

Location is pinpointed by using a receiver, like a cellular phone, and precisely timed signals it receives from GPS satellites in space. Satellites are constantly transmitting messages including temporal and positional data. Using the speed of light, the receiver determines how long it took the satellites to transmit the data. The location of each satellite defines a sphere, so the point at which the spheres intersect would be the receiver's exact location.

Current Leading Vendors: eTrack, LiveViewGPS

Airport / Airline Examples:

- London City Airport is the first airport in Europe to offer the AirPort baggage delivery service, which allows travelers to have their luggage securely transferred to and from the airport, London's hotels, serviced apartments and offices. The service allows travelers to head straight into London without having to worry about carrying their bags with them, and as it includes a mobile-based GPS luggage tracking facility, customers can check on the location of their bags throughout the process.
- Air France and KLM use eTrack, which makes use of GSM, GPS and Bluetooth technology, which enables it to be tracked by a smartphone. Passengers with a "Flying Blue" account can link the eTag and eTrack devices to their account, so when they check-in online, the permanent bag tag will be automatically updated within just five seconds. The tag communicates with the outside world via the eTrack device, and directly with smartphones using Bluetooth. Both products can, however, also be used independently.

Global System for Mobile Communications (GSM)

Global System for Mobile Communications (GSM, originally Groupe Spécial Mobile) is a standard that was developed by the European Telecommunications Standards Institute (ETSI) and describes a protocol for 2G cellular networks. It is the default worldwide standard for mobile communication and is available in over 219 countries and territories. Originally developed as a replacement for analog cellular networks, it described a digitally circuit-switched network with an optimization toward full duplex and voice telephony. When making a call over GSM, the phone converts analog sound waves of speech into digital data which is transmitted through a mobile phone network. Currently, there are five codecs (encoded speech signals) employed in GSM: Half-Rate (HR), Full-Rate (FR), Enhanced Full-Rate (EFR), Adaptive Multirate (AMR) and Wideband AMR, more commonly referred to as HD voice. Except for AMR, all of the codecs operate with fixed error connection levels and data rates. GSM offers the ability to send and receive data, voice calls, and short message service (SMS) or "text messages". VoIP can also be utilized.

Throughout the years it was improved into 3G GSM and included data such as GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS). Although, 4G and LTE technologies are strongly emerging globally, GSM is still relevant as a global standard (covering approximately 80% globally, including most of China and India), and will continue to grow alongside 4G/LTE. The GSM Association owns the trademark "GSM".

Current Leading Vendors: Samsonite, eTrack, GlobaTrac LLC

Airport / Airline Examples:

- Air France-KLM in collaboration with input from their SkyTeam partner Delta Air Lines uses RFID bag tags that combine the usage of GSM, GPS, and Blueooth technologies to track baggage through airports.
- GlobaTrac LLC offers a product available for consumer use called TrakDot, a luggage tag which utilizes the company's own GSM frequency to track the location of a bag. Made available to the public in 2013 they run on two AA batteries and the software automatically sends text messages to the user with information about the location of the luggage.

Indoor Positioning/Navigation Technology (IPNT)

Indoor Positioning/Navigation Technology (IPNT) is a technology similar to Global Positioning Systems (GPS) but used inside buildings. It is used to determine a person or place's location that GPS cannot. By utilizing GPS technology along with Wi-Fi, certain companies have been able to sharpen their IPNT to an accuracy within 1.5 meters. A plethora of access points as well as carefully measured radio environments in a building is the key to pinpointing a fixed location. Maps are then created using information about the interior of the buildings. Such maps can also be made available to passengers either within an existing airport map, or as a stand-alone map application. Running such an app on mobile devices, a passenger can find his/her location on the airport campus and can proceed to other locations using the map as a guide. The mobile devices themselves function as the trackers by which the airport can gather relevant data about locations and movements.

Enhancing the map through augmented reality or context-aware mobile application solutions allows the airport to incorporate and make available additional information as the user navigates through the airport. This can be done actively by using the device's camera to scan the environment while running an AR app, or passively by simply passing by sensors often located at travel touch points (such as security) or concessionaires (restaurants and shops). This way, the airport can provide push notifications if a device is close enough to a sensor/beacon, or incorporate personal information previously stored in a Context-Aware mobile app. This type of functionality can be leveraged greatly for improved customer service, marketing purposes, and to create business opportunities for the airport and its tenants. Low cost, simplicity of use and the fact that hundreds of thousands of people already have transmitters and receivers in their mobile devices makes this a seemingly easily deployable solution.

Current Leading Vendors: Apple, Google, Insoft, Qualcomm

Airport / Airline Examples:

- Mineta San Jose International Airport set up an indoor positioning system using Apple's CoreLocation API. It allows developers to create indoor maps and services that communicate with the iPhone processor and motion sensors.
- Frankfurt Airport is another airports which offers a comprehensive indoor positioning and navigation app (by Infsoft) that includes some unique features, such as a parking assistant and options to set specific airport locations as destinations, that set them apart from others.
- 23 U.S. Airports (and 60+ worldwide) have worked with Google to create indoor maps. Google provides indoor walking directions
- Paris-Charles de Gaulle Airport offers a new indoor geolocation Android app, which provides directions to various services throughout the airport. The 'My Way Aéroports de Paris' application covers an area of 200,000sqm. It is divided into sections – Routes, Leisure, Services, and Favorites.

Iris/Retina Scanning

Iris scanning uses an advanced digital camera to capture four main parts of an individual's eye: pupil center, eyelids and eyelashes, pupil edge, and iris edge. The associated software then creates a code based off of the information. This technology is much more accurate than fingerprint scanning because there are 200 unique identifiers in an iris as opposed to around 60 contained in a fingerprint. Like fingerprints, the iris has an incredibly unique texture that is randomly generated during gestation. It is fairly easy to use since a photo can be taken from 10cm to a few meters away. This makes increases user adoption of this technology as they do not have to touch any surfaces that may have been previously used. Typically, iris scanners use Near Infrared (NIR) light as well as a single LED to illuminate the eye for a sufficient capture of characteristics. Eye safety is taken into consideration when developing and continuing to study iris scanning as NIR as well as multiple LEDs have the possibility of damaging the eye.

Often confused with iris scanning and similar in many ways, retina scanning actually goes a step forward using similar lighting to scan the blood vessels of the back of an individual's retina. It is even more much more accurate than iris scanning because of the extraordinary uniqueness of each user's retinal blood vessels. It is, however, not widely adopted because it requires any eye wear to be removed and the eye to be put directly against the scanner. Retina scanning is quite expensive s only widely deployed in situations where a high level of security needs to be maintained.

Current Leading Vendors: Vision-Box, Human Recognition Systems (HRS), AOptix

Airport / Airline Examples:

- Amsterdam's Schiphol airport uses iris scanning as an alternative for passports during the customs and immigration process. This Privium membership, which offers quick border passage, has reached almost 50,000 members.
- Hamad International Airport in Doha installed 62 automated border control e-gates (vb i-match eGates supplied by Vision-Box). They are tailored specifically to the requirements of the Airport, and make use of face, iris, and fingerprint recognition technology to ensure the highest possible level of accuracy and border security and to support the airport's vision to create a seamless travel experience.
- Gatwick Airport and Human Recognition Systems (HRS) provide an end-to-end biometric solution (MFlow – using iris and facial recognition) to validate passengers at all stages of the process and to manage passengers across a series of identity points – from car parking to ticket production to purchasing a discounted product in the retail space. It enables Gatwick to automate passenger identification, enhance its overall passenger experience, and grow the airport's non-aeronautical revenue.

Near-Field Communication (NFC)

Near-Field Communication (NFC) is a form of short-range wireless communication that using antennas does not communicate by radio or electromagnetic waves, but by either a modulated electric or magnetic field. Typically they require a distance less than 10cm to operate. NFC uses the 13.56 MHz band on ISO/IEC 18000-3 air interface, varying in rates from 106 kbit/s to 424 kbit/s. NFC allows for two-way communication while RFID is limited to one-way. Unpowered NFC "tags" are readable by NFC devices and could potentially rival RFID systems. Applications that are expected to successfully deploy NFC include transfer of data, communication (through an NFC "tag"), and contactless transactions. Many cellular phones use electric-field NFC due to the security it lends itself to for certain transactions.

For contactless payments, for example, the level of encryption is very desirable and implements tokenization of data in order to further guarantee privacy of information. In many arenas NFC is used to piggyback on other technologies. For example, smartphones can be equipped and paired with an NFC "tag" or sticker which can be programmed by an app to automate tasks such as creating text messages or executing commands. NFC tags are usually read-only containing a specific set of data but in some cases are rewriteable. They can either use specifications set by the industry association, the NFC forum, charged with promoting and setting key standards for the technology, but can also be custom-encoded by their manufacturers. Memory bytes in tags range from 96 to 4,096 at this time. NFC is not bound to a specific company and can therefore be used by anyone who has the technology.

Current Leading Vendors: Panasonic Avionics, SITA, Amadeus, IER, RESA

Airport / Airline Examples:

- Air France, Amadeus and IER partnered with Nice Côte d'Azur Airport to implement NFC-based boarding passes for members of the Club Airport Premier (CAP) passenger program.
- In 2014 Air France has partnered with Orange, SITA, and RESA to trial Near Field Communication (NFC) boarding passes at Toulouse-Blagnac Airport.
- Amsterdam Airport Schiphol has installed a Near Field Communication (NFC)-ready boarding gate as part of its long-standing collaboration with SITA. Using an NFC-enabled mobile phone, passengers will be able to pass through the boarding gate simply by tapping their phone on an NFC reader, even if the phone is turned off.
- Panasonic Avionics has announced that it will introduce Europay, MasterCard, and Visa (EVM) compliant Near Field Communication (NFC) technology in its in-flight entertainment (IFE) systems in 2015.

RFID (Radio-Frequency Identification)

RFID tags are small chips that contain specific information that can be modified, added to, or subtracted from. This is in contrast to barcodes which hold only static information. RFID technology uses electromagnetic fields to wirelessly transmit data from transmitters to an antenna for the purpose of automatically identifying and tracking tags that can be attached to objects. RFID tags are often chosen in cases of "touch-to-pay" services. The tag can be far away and experience interference between it and its reader, or be embedded in tracked objects. Bands can operate (from shortest to longest range) at 120–150kHz (10cm) to 3.1–10GHz (200m). This versatility has made RFID technology the go-to technology when it comes to tracking. Airports often use RFID technology to track the movement of baggage and locate lost luggage. RFID tags are also used by many airlines as a way for passengers to tag their own bags quite efficiently.

While safeguards are put into place, there has not been found a way to guarantee 100% full security of RFID data. In the UK, the RFID tag encryption implemented in passports was broken in under two days. Due to that level of compromise, if a criminal gained access to the RFID chip they could in essence make an exact copy or change the information it holds. Nevertheless, there are measures that can protect RFID breaching. The US General Services Administration (GSA) implemented test procedures on electromagnetically opaque sleeves. A standard was then set for shielding products. Today, the US government demands that any new ID card containing an RFID chip must be housed in an effective holder.

Current Leading Vendors: Motorola, Intermec, DESKO

Airport / Airline Examples:

- Australia's Qantas airlines as well as Las Vegas McCarran's airport provide reusable RFID bag tags which allow employees to sort and transfer baggage quickly.
- Airbus advanced the application of baggage technology by embedding an RFID chip into its 'smart' luggage prototype 'Bag2Go', that allows tracking the chip via the 'Find my Bag' function of the bag's accompanying iPhone app.
- On its Frankfurt – Tokyo Narita route, Lufthansa provides an RFID-enabled bag tag sleeve for home–printed bag tags. Attached to the passenger's luggage, this sleeve also includes a home-printed boarding pass in form barcodes. The luggage can then be dropped off at any of the airlines self-service bag drop kiosks at either airport. The tag also includes an additional QR code, therefore travel details can be reconstructed if the RFID tag has been damaged.

SmartGlasses

Smartglasses are wearable display technology units with built-in intelligence. They can range from offering only simple data displays to those using wireless connectivity (e.g., WiFi, 4G, and Bluetooth) for application and data processing, even incorporating complete systems comparable to Android or iOS systems. They generally include cameras and high-definition video. The units are equipped with a heads-up display (HUD) for the user using a projector to project images onto the eyeglass lens that equates approximately to a 25-inch display from approximately 8 feet away. Users can check their email, search websites, take pictures, and use Bluetooth to sync with a mobile device.

Similar to smartphones and smartwatches, smartglasses are intended to integrate a user's real world with the virtual world. With any technology products, prices differ based on functionality. Impacting the consumer's choice for smartglasses, however, also includes how much the units look and feel like regular glasses. Application of smartglasses in an airport environment include them being worn by airport/airline staff at the entrance to security, at the gate, or at the aircraft door to identify passengers using facial recognition technology, among others. Passengers can use smartglasses integrated with augmented reality applications to overlay information onto airport maps, which allows the user to be guided visually to the gate. This can include an alert when boarding time approaches, or estimating how long it would take the user to reach the gate from the current location.

Current Leading Vendors: Google, Vuzix

Airport / Airline Examples:

- Copenhagen Airport with SITA Labs trialed Google Glass to help answer passengers' questions relating to their airport journey, thereby avoiding customer service desks visits. Airport staff also used these smartglasses to document untidy departure gate areas – using pictures and videos – after a common use transfer between airlines.
- Other airports, such as London City Airport, have been exploring how they can leverage Google Glass from an airport operations perspective.
- Virgin Atlantic trialed Google Glass and Sony Smartwatch in the Upper Class Wing at London Heathrow Airport. The carriers equipped concierge staff with the devices to personally greet travelers by name, provide travel-related information in real-time, and initiate the check-in process prior to the traveler reaching the terminal.
- Allegiant Systems envisions that Vuzix-based smartglasses could help First Class flight attendants to improve service to premium passengers.

SmartWatches

Smartwatches are wristwatches that use computerization for tasks far more complex than telling the time. Although they are in a relatively newborn state in the realm of technology they have already broad capabilities and can be as advanced as smartphones. Some sample applications include GPS, calculator, thermometer, camera, and media playing capabilities, as well as capabilities of tracking heartbeat, steps taken, and miles traveled. With the addition of faster processors, capabilities will continue to be diversified and advanced. Smartwatches generally use Bluetooth to connect with a user's phone, if not Wi-Fi and GPS are less popular options. However, Bluetooth Low Energy is emerging as another option. Due to the small displays sizes, ranging from 1.25 in to 1.63 in, resolution and sharpness is always an area of concern. Also, other components such as more flexible and enduring glass are in development; so is the aspect of weight which generally does not exceed 2oz.

This technology can be quite beneficial to passengers by having calendar or flight reminders pop up, as well as display and scan boarding passes. Smartwatches, although gaining momentum, are still not mainstream. However, they will continue to advance in terms of technical capabilities in general and applicability to travelers in particular; and users will be able to choose from models covering various price-points to meet their individual needs.

Current Leading Vendors: Samsung, LG, Sony, Pebble, Motorola, Google, and Apple

Airport / Airline Examples:

- Various airlines have partnered with different vendors to provide smartwatch-based boarding passes. Spanish carriers Vueling and Iberia utilize Sony's Smartwatch 2 and Samsung's Gear 2, respectively, whereas Air Berlin offers their passengers to send their mobile boarding pass from within its iOS-based app to a Pebble smartwatch.
- Virgin Atlantic trialed Sony Smartwatch (in conjunction with Google Glass) and in the Upper Class Wing at London Heathrow Airport. The carriers equipped concierge staff with the devices to personally greet travelers by name, provide travel-related information in real-time, and initiate the check-in process prior to the traveler reaching the terminal.
- Japan Airlines has equipped its gate agents at Tokyo's Haneda Airport with smartwatches, enabling them to receive location-specific tasks from the control desk, which can track their whereabouts using iBeacons.

Speech Recognition

Speech Recognition (SR) technology, including Speech-to-text (STT), is widely used in most smartphones as part of the search feature, as well as text and email applications. It is the translation of words spoken aloud into text by a computer process. SR is usually a means to an end for other more advanced applications. In the simplest forms, it is used for data entry, document preparation, searching purposes, and hundreds of other easy tasks. Challenges with this technology increases as the vocabulary is widened and also, as with voice translation, when a user has a hard to decipher accent or way of speaking. Background noise is also a factor in accuracy. Acoustic modeling and language modeling are both significant parts that make up modern statistically-based speech recognition algorithms. Hidden Markov models (HMMs) are the most popular algorithms used. These statistical models output a sequence of symbols, which are then viewed in very small pieces (e.g., 10 milliseconds). Then, another algorithm is used to decode the coded speech into what the user ends up hearing.

A more promising SR technology in regard to passenger self-services is Voice Command. It is used substantially in automated call-center applications as well as in smartphones. In reference to the latter, Apple and Android-based smartphones utilize voice-activated “personal assistants” to enable the user to perform tasks without having to type. This type of application can be of great benefit to an airport as part of an integrated self-service strategy. It could be an additional value-added feature to Virtual Assistants, which are increasing in popularity across the world.

Current Leading Vendors: VeCommerce, ProNexus, Nuance, Microsoft, Salmat

Airport / Airline Examples:

- Dallas Forth Worth International Airport updated its existing airport mobile phone app to include a “Voice Concierge” feature. Questions spoken into the Smartphone’s microphone will redirect the user to the appropriate requested content within the airport app.
- Dubai Airport installed a voice-activated system within their existing call-center solution that can provide updated flight information to the passenger/caller.
- Dublin Airport Authority implemented Salmat's automated natural language speech recognition solution to resolve their contact center issues. The solution enables callers to establish real-time flight information by recognizing responses and answering with the appropriate flight information.

Synthetic Intelligence

Synthetic, or artificial intelligence, uses several infrared transceivers about a foot from the floor that emit a system of beams, creating a zone. This form of passenger counting and is also able to evaluate which direction the person is traveling in. Unique to synthetic intelligence is the ability to determine whether or not an object traveling through the zone is a human. Like thermal imaging, it can count in the darkness. As with beam counters, however, people and objects can block the zone. This technology also requires a substantial investment due to amount of transceivers needed.

Passenger count is determined by using the speed of light, taking the travel time from when the light is sent to when it is received, dividing by two and multiplying by the speed of light. This results in an accurate calculation of the distance from the sensor to the object (in this case, the human) passing through the field. Saturating the travel industry, synthetic intelligence is primarily deployed in Bus and Rail systems. Examples of airport deployment are consistently found to be in passenger transport within the airport (e.g., terminal-to-terminal trains).

Current Leading Vendors: Irisys, IRIS

Airport / Airline Examples:

- San Francisco International Airport and Phoenix Sky Harbor International Airport use an array of IRMA5-Matrix infrared sensors at the entrance of their SkyTrain station door to monitor passenger flow.

Thermal Imaging Systems

Thermal imaging systems are used by distinguishing heat emitted by a person's body to count both passenger flow and direction. These systems are more versatile than beam counters because they are mounted on the ceiling and have a lesser probability of being obstructed. The size and shape of these passenger counters can be likened to a home smoke-detector. Thermal counters require no light, are almost 100% accurate, and can cover a vast amount of area versus their less capable counterparts, which are typically limited to a 10x10 feet space.

However, weather conditions can affect the readings negatively. Due to the significant advantages and the required training to operate and interpret data output, these passenger counters are considered a substantial investment and a rather costly solution. Thermal imaging systems would be ideal for an airport that intends to make it their long-term solution and commit to utilizing it for passenger flow measurement after they have considered the other options and determine it is best for their specific situation.

Current Leading Vendors: Irisys, SITA

Airport / Airline Examples:

- Dubai International airport has taken an approach in the realm of passenger counting including thermal imaging passenger counters from Irisys.
- Charles de Gaulle Airport in France is also using a multi-solution passenger counting platform that includes thermal imaging by Irisys.
- Tampa International Airport in Florida has rolled out a three-tiered solution including thermal imaging to manage security queue times.

TransferJet

TransferJet is an emerging technology that deals with close proximity wireless transfer of data. Instead of using radiation-field technology it uses couplers based on electric induction fields. The basic parts of the coupler include an electrode or plate, a stub, and a ground. It achieves higher transmission gain and more proficient coupling in the near-field. Developed by Sony, it permits quick data exchange by touching two electronics together. Its concept includes a touch interface which can be used in environments that need peer-to-peer transfer without external connectors. The operational maximum throughput is currently 375 Mbps. The technology will automatically lower the rate according to the wireless environment, upholding a dynamic and vigorous transfer rate independent of the condition of the wireless environment.

Although this technology is somewhat similar to NFC, it provides added functionality, especially in regard to high-speed data transfers, including the capability to transmit larger files between coupled devices. TransferJet is one of the wireless drivers that is expected to eliminate the need for physical connections to interface devices with one another.

In addition, the industry is looking at this technology to be integrated with the wireless charging of electronic devices.

Current Leading Vendors: Toshiba

Airport / Airline Examples:

- Toshiba recently revealed a compact touchscreen kiosk which offers music, videos, and other forms of entertainment for immediate download. With the appropriate software, payment is automatically initiated as well.
- In addition to the above, Qi stations that will charge a smartphone or tablet's battery almost immediately are expected to be rolled out in airports worldwide. Again, this has been announced in 2014 and is still in the development stages.

Vein Matching

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Video Analytics

Video Analytics refers to technology used to acquire a 3D image of a location using at least two cameras, and use an algorithm to accurately determine the amount of people in a certain area. The larger the space and the higher the ceilings, the more cameras need to be used. Typically an airport will have to invest in the cameras, the video analytic software, and most use consultants or IT firms to advise how to use the systems. The cameras send their data to the analytical software which then interprets it and determines either how long wait times are at security checkpoints, or even what the peak times are in certain areas of the airport due to specific passenger flow patterns.

This technology is especially effective to help solve problems of overcrowded areas as well as determine the direction of people in motion. Depending on which type of video analytic used, the cameras can utilize emitted light to further pinpoint each person in the space. In some cases, many windows offering natural light can affect the results of the analysis. Like thermal imaging, it is widely used due to the ease of deployment and the high degree of accuracy. It was primarily developed to address high-traffic environments.

Current Leading Vendors: NICE, SightLogix, ICx Vision Systems, Vident, Blue Eye Video

Airport / Airline Examples:

- Washington Dulles International uses video analytics from Blue Eye Video to alert passengers of approximate wait times so they can make informed decisions.
- Charles de Gaulle Airport uses Blue Eye Video to manage their queue times and commented that they picked this solution because it works even though they have very high ceilings.
- Vantaa Airport in Helsinki, Finland, is using video analytics purchased from Vident that will automatically alert when there are long wait lines at the security checkpoint, enabling the airport to open more lanes.

Voice Biometrics

Voice biometrics, one of the primary emerging behavioral identifiers, analyses acoustic patterns in speech based on a user's anatomy as well as taking into consideration pitch and speaking style. Another name for voice biometrics is speaker recognition. While voice recognition can mean speech and speaker recognition, it needs to be noted that this technology addresses the need for identifying the speaker rather than the content of what is said. The results of a recording can be measured against a voice recording in a database to authenticate a user, or it can be measured against all voices in a database to identify a specific user. It is sometimes used, in a limited application to identify the gender of a person calling a customer service call center.

A problem with this form of biometrics is that if the individual is sick, stressed, tired, or in any other than "normal" condition, it would cause the pitch and pattern of the voice to change. Also, recordings can be used in some situations which can "beat the system". A benefit, similar to that of vein matching, is the fact that it is no invasive, because speaking is natural and typically does not make the user feel uncomfortable.

The application of voice biometrics as it pertains to airports is virtually non-existent at the time of this writing. Some predict, however, that voice biometrics could be used in airports in terms of security and wayfinding but this would require a great deal of effort in order to deploy. This is by far the most emerging of all biometrics and development as well as future deployment will be something to watch in the upcoming years.

Current Leading Vendors: Nuance, Pronexus, FST21

Airport / Airline Examples:

- Tel Aviv's Ben Gurion Airport uses FST21's biometrics including voice authentication as an additional security measure.
- Dubai International Airport uses speaker recognition at their call centers to identify whether the caller is male or female and to assist in lowering queue times on the phone.

Voice Translation

Voice translation deals with translating spoken words, phrases, and sentences from one language to another. Speaking into a microphone, a person's speech is turned into a string of words, before an application translates it (to the best of its ability placing it in context). Then a speech synthesis module uses waveforms similar to the text, pronunciation, and intonation to produce an audio output. This technology is especially helpful in the context of international travel, such as in airports that function as international transfer hub. Three software technologies are usually integrated to achieve this function: automatic speech recognition (ASR), machine translation (MT) and voice synthesis or text-to-speech (TTS). The first recognizes the speech and compares it against a database, the second translates the utterance, and the third then assumes how it is pronounced and spoken. Challenges to overcome include how to handle accents and slangs, for example, as well as tuning out background noises, such as in busy airport lobbies.

At the time of this writing, Skype in conjunction with Microsoft Research, developed a near real-time instant messenger language translation tool, called Skype Translator. Using neural-network-based speech recognition technology this tool enables users, although speaking different languages, to communicate via video chat. Airports can use benefit from such, or similar, functionally by possibly integrating it with information kiosks already offering live communication with airport customer service representatives.

Current Leading Vendors: NEC, Microsoft, Skype

Airport / Airline Examples:

- Japan's Narita airport offers voice translation application, NariTra, produced by Narita Airport to overcome the language barrier. NariTra converts a user's words into other languages simply by speaking into their Smartphone.

Wi-Fi

Wi-Fi (sometimes spelled Wifi or WiFi) is a wireless local area network (WLAN) technology that lets compatible electronic devices (e.g. smartphones, tablets, audio devices, smartwatches, laptops, etc.) connect to the internet using a wireless network access point (or hotspot) to upload/download information. There are two different radio waves utlized: 2.4 GHz UHF and 5 GHz SHF. A wireless access point (WAP) connects a group of wireless devices to an adjacent wired LAN. An access point is like a hub, relaying data between connected wireless devices in addition to one or more connected wired devices, letting other wired devices communicate with the wireless ones. Wi-Fi in the 2.4 GHz frequency block has a slightly better range than Wi-Fi in the 5 GHz block. Multiple hotspots can be set up to overlap and expand the range. The coverage of an access point is affected by the kind of infrastructure architecture it operates in and how many access points are connected.

Wi-Fi is less secure than a wired connection (such as Ethernet). This necessitates security encryptions, which differ in regard to the level of security required or desired by the user of the device. Wired Equivalent Privacy (WEP) is the most common type of encryption and unfortunately is easily breached. Wi-Fi Protected Access (WPA and WPA2) encryption was introduced in 2003 as a solution, but there is still much left to be desired. In order to enable any real amount of security the user must configure the device, something that many novice users are incapable of doing.

Sometimes, concessionaires and other airport stakeholders, offer their own Wi-Fi, which in a sense "competes", with the existing airport-offered network. Since most laptops and virtually all tablets and smartphones have wireless connectivity capability, it is almost expected that all stores, restaurants, and airports that people visit have access to Wi-Fi.

Current Leading Vendors: Any ISP, Boingo

Airport / Airline Examples:

- Virtually all airports, and many of the concessionaires and other airport stakeholders, offer WiFi connectivity. Airport WiFi can be free of charge, or offered for a fee.