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Disrupting Complex Systems with Emerging Technologies: A Study on United States Airport Operations

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Disrupting Complex Systems with Emerging Technologies:
A Study on United States Airport Operations
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Abstract

The number of United States domestic commercial flight passengers are growing every year, which means the number of people checking-in, dropping off their bags, and going through TSA within airports is equally growing. With the increasing number of passengers and aging airports, there are several areas of pain points within airports where passengers hit a bottleneck due to the current systems that airports have in place. There are three main areas that we are going to reference. First the check-in process, where customers have to get their tickets, input identification information, and check-in for their flight. Second, baggage-drop off, where customers get their baggage weighed and tagged. Lastly, is Transport Security Administration (TSA). This is where consumers get their carry-on bags scanned as well as their person.

In each of these areas, there are some levels of inconvenience imposed on the customer by the current system. With technological advancements being used in other industries, the goal of this thesis is to look at what existing technologies can be modified and used within airport operations to reduce the long lines that customers face every time they travel.

Keywords: airports, emerging technologies, baggage, security, check-in, TSA, automation

Disrupting Complex Systems with Emerging Technologies:

A Study on United States Airport Operations

With over $1.1 trillion spent annually by American travelers, the air-transportation industry is not going anywhere, anytime soon. However, airports within the United States have been faced with increased traffic, "United States carried an all-time high of 965.0 million systemwide (domestic and international) scheduled service passengers in 2017, 3.4 percent more than the previous record high of 933.1 million reached in 2016" (Smallen, 2018). At the same time "'the airline industry has been on a steady downward trajectory when it comes to customer service for nearly 40 years,' said Henry H. Harteveldt, the president of the Atmosphere Research Group, a travel industry research firm" (Manjoo, 2017). A 30-minute wait in check-in lines was equal to about a 10% decrease in airline perception so airports also play a piece in the decrease in customer satisfaction. (Hemlich, 2016).

Another reason for this decrease, beyond the lines, when thinking about the past five years of air travel experience, 51% of survey recipients say it has become more of a hassle and 17% saying they did not know (The Air Traveler Agenda, 2017). This is a massive percentage of people who face some kind of inconvenience, which could be due in some form to the infrastructure.

Although "some airports have made or are making major investments in capacity additions—including new runways—like those recently built at Atlanta (2006) and O'Hare (2012), "the FAA estimates that 14 of the top 50 airports will still face capacity constraints even after planned improvements occur" (Thanksgiving in the Skies, 2014). Since the newest U.S. airport, Denver was built in 1994, the infrastructure of airports has not changed very much. Some the airports have added runways, such as Chicago's O'Hare International Airport and Seattle-

Tacoma International airport, which is increasing the number of planes flying in and out,

therefore increasing passenger traffic. Meanwhile, there are no drastic improvements being made

to the interior of airports. Between 2017-2021 the infrastructure of United States airports needs

is estimated to be about $100 billion ("U.S. airport infrastructure needs near $100 billion," 2017).

This number is so drastic because, since 2015, the needs have increased by 32% each year.

Although there are lots of needs, some airports, such as Altana's with their facial

recognition check-in system and new TSA Security Systems in Baltimore-Washington

International Airport, are making improvements but with over 500 commercial airports in the

United States these improve are few and far between ("US Department of Transportation"). Yet

airports are continuing to age, and the number of travelers each year is growing domestically by

an average of 3% annually (Smallen, 2018).

With no direct alternative insight, the major problem areas within airports need to be

identified and solutions need to be found so that travelers can feel more satisfied with their

experience or at the very least allow satisfaction levels and line lengths to stay constant with the

increase in passenger volumes. Since the satisfaction of airlines is affected by airport

efficiencies, that could affect an airline expanding to certain airports if their wait times are high.

Beyond satisfaction, in 2015 31% of passengers were flying on business. For traveling

professionals time is extremely important. The less amount of time wasted the better. Airports

need to find a solution to decrease the time spent within lines, which, for 48% of leisure fliers

could also mean more time spent shopping with internal shops and increase flyer satisfaction.

(Heimlich,2016)

In conclusion, airports are facing a seemingly impossible challenge – higher volumes, old

infrastructure, and low willingness to pay extra from both passengers and governments. This

challenge faces the need for innovation which brings in the need to do more with less. Bringing these two thoughts together, airport challenges and innovations, the goal is to answer the question, what emerging technologies, or pieces of current technology, can be used within commercial United States airports to help alleviate some of the problems that arise within the current systems?

Literature Review

The following sections will discuss areas that are important considerations when determining disruptive solutions for the current United States airport. There is a wide variety of subjects that will be discussed in order to get a greater understanding of the situation and the possible solutions available to the airport industry. These areas range from the types of emerging technologies that could be useful within airports to the areas of pain, or delay, for the customers in U.S. Domestic airports. With a greater understanding of these areas, the reasons for the chosen technology and pain point parings will be discussed later on.

Human-to-Machine Interactions

The world is changing to a more machine-driven society. Our cash registers are completely automated, and motor vehicles are not far behind. People are now saying that they prefer self-service machines over employee-led options. (Collier & Kimes, 2015) This is only the case, however, when the machines are implemented well and tested for user errors. During the initial set- up, users expressed a "need for employee interaction during a self-service experience, especially when customers were exhibiting technology anxiety" (Collier & Kimes, 2015). This anxiety is usually brought on by the untried system and their lack of knowledge with using it.

When an employee was nearby users felt more comfortable with the possibility of making a

mistake in the process because the employee would be able to fix their error.

Human error is one of the elements that the system should be tested for when in

development because "even if end-users are provided with excellent user interfaces, errors will

still happen if people are expected to work in noisy environments or cramped conditions against

tight deadlines" (Boy, 2011). In addition, the consideration for when users are purposefully

misusing the interfaces is a major concern for security applications. The goal is no to make the

system so that users cannot "break" it.

One way to help eliminate this is called resilience engineering. "This assumes that we

should focus less on the causes of human error and more on the promotion of recovery actions"

(Boy, 2011). It can be assumed that "humans are not simply the cause of error; they act as a key

means of mitigating failure in complex systems. This is a critical observation" (Reason, 2008).

Due to the interaction of humans it is important to understand their actions within a system and

how they will interact with the process. This can be done by using simulations and watching how

a personal interaction with the machines and trying to anticipate their next move. (Boy, 2011)

The development period of self-service machines is crucial for allowing the systems to

reach their full potential and to satisfy the primary reason these machines are used, convivence.

More specifically, transaction speed is the largest influence for customers using these machines.

For example, the "U.S. Customs and Border Protection agency has installed automated passport

kiosks for customs screening at numerous airports. The kiosks have been a success and have

reduced wait times significantly" (Collier & Kimes, 2015). If these machines were slower than a

border patrol officer, there would still be a need to have them. The human-human interaction can

cause the customers to be less satisfied with the experience due to lines and also issues that come with human-error, such as incorrect information inputted into a computer. So even if the waiting process was a little slower with machines but cheaper than having officers this would be a beneficial system to implement.

Complex Systems

When assessing complex systems that combine technology with human interaction it is important to understand a few theories: Digirati and Sociomateriality, as well as how to innovate. These systems are best thought of as machines with lots of moving parts, some of which included the technology itself as well as the human user involved. Any input made by the user can affect how the technology responds and therefore the results the user gets.

Digiterati

Digiterati is a term used for companies that "combine digital activity with strong leadership to turn technology into transformation." Companies whose systems incorporate the use of technology and customer experience are more likely to remain in business for longer periods of time. To do this "executives are digitally transforming three key areas of their enterprises: customer experience, operational processes, and business models" (Westerman, Bonnet & McAfee, 2014) and within each of these areas are 3 more subtopics.

The first being transforming customer experience. To transform the customer experience, enterprises look at customer understanding and how the company uses their systems to gain an in-depth understanding of market segments. This can be using social media interactions with customers to gage who is interested in their products. They also look at top-line growth, which is

using mobile tools to make a sales pitch and, in the end, make a sales conversation. Lastly, to transform the customer experience use customer touch points such as Twitter to interact with customers and help answer any questions they may have. (Westerman, Bonnet & McAfee, 2014)

Digiterati companies then look to transform the operational process. They first look to process digitalization. Companies look to automation because it "can enable companies to refocus their people on more strategic tasks" (Westerman, Bonnet & McAfee, 2014). Instead of HR focusing on handwriting checks they can work on creating training programs for new employees. Worker enablement is also a form to transform the operational process. This uses technology to help organize workers based on all of their different work assignments so that "individual-level work has been virialized" (Westerman, Bonnet & McAfee, 2014). Lastly, performance management is when "transactional systems give executives deeper insights into products, regions, and customer, allowing decisions to be made on real data and not on assumptions" (Westerman, Bonnet & McAfee, 2014).

Finally, when transforming their business model companies will looking at their big picture operations and how they do business. First, for digitally modified businesses, "One media executive said: 'We've realized that if we don't transform the way we do business, we're going to die. It's not about changing the way we do technology but changing the way we do business'" (Westerman, Bonnet & McAfee, 2014). It can be easy for a business to add new technologies to their business but if the entire business does not start revolving around these advancements no big changes will occur. Next is called new digital business, this use incorporating digital complements to traditional products. For example, airports kept their old paper tickets but added barcodes to the tickets and scanners at various stages within the airport to complement the use of tickets rather than having humans look over the tickets. Finally, digital globalization, "companies

are increasingly transforming from multinational to truly global operations. Digital technology

coupled with integrated information is allowing businesses to gain global synergies while

remaining locally responsive" (Westerman, Bonnet & McAfee, 2014).

All of these nine touch points allow businesses to understand where they can improve

their uses of technology within business operations to most efficiently digitize their operations.

Digiterati companies combine present operations with the most advanced technologies to keep

their companies strong.

Sociomateriality

Sociomateriality has been described by saying "the social and the material are considered

to be inextricably related — there is no social that is not also material, and no material that is not

also social" (Leonardo, 2013). In this case, the social can be used to describe the human

interaction or organizational structure, and the material is the technology being interacted with.

Some theorists "advocate for a deterministic relationship between technologies and

organizational structures." They think that the technology and organizational structure go hand-

in-hand. This is because "people could rebel and use the technology differently, which would

then lead to a change in the (organizational) structures of signification, legitimization, and

domination" (Leonardo, 2013). When the technology is not used in an intended way there is a

possibility that the entire organization is now working in a different way, similarly to how WD-

40 was originally used for lubricating missiles and now people use it for squeaky household

items.

In other situations, instead of using technology in a rebellious way, people may perceive

the technology to be of no use for them,

perceiving instead that it's constraints their ability to carry out their goals. In this view,

affordances and constraints are constructed in the space between social and material

agencies. Peoples' goals are formulated, to an important degree, by their perceptions of

==what technology== can or cannot do, just as those perceptions are shaped by people's goals.

(Leonardo, 2013)

This can be detrimental to the products. If the product is not inviting and does not give people

the idea that they would benefit from using this product, but rather they will actually be unable to

carry out their intended goal then there is a disconnect between the social and material aspects.

Researchers "also need to examine how people come to understand, interpret and deal

with the materiality that pre-exists their interaction with technology and how this existing

materiality becomes imbricated with the social contexts into which it is introduced" (Leonardo,

2013). There needs to be an understanding of how people deal with the material, in this case, the

product that uses the technology, and any pre-existing assumptions of the product before

deploying it into use.

 In general, Sociomateriality looks to understand how people will interact with products and

anticipate any issues that may incur. It is important to consider when looking to add new

technology within a preexisting or new operation because the users, or social element, will be

affected by the material and the material will affect the social aspects.

Innovating within Complex systems

Constant innovation is key for a company to continue operating over time. In a discussion

with Michael S. Hopkins, Michael A. Cusumano was asked to answer some questions about the

material in his new book, *Staying Power: Six Enduring Principles for Managing Strategy &*

Innovation in an Uncertain World. One of the questions he was asked was "Given the speed of

technology change and its effect on competition, what should leaders pay most attention to about

their own companies in order to position them to evolve and succeed?" (Cusumano & Hopkins,

2011). Cusumano said that Agility and the ability to develop deep differentiating capabilities was

the most important to pay attention to.

Agility because companies need to be able to change quickly and adapt the unexpected

changes in their ecosystem. This is the most important element to evolving and succeeding. If a

company cannot act quickly and change their business ways when it is needed, they will not

survive.

The need to develop deep differentiating capabilities refers to the need to be different in some

way. In a world where there are so many options to one product, it is important to stand out in

some way, whether it is the manufacturing process, the product design, or the mission behind the

company. There needs to be some way to differentiate.

Airport Pain Points

The airport pain points are areas that customers frequently have issues with and have

complained about. More specifically, the major issue with each of these areas of the airport is

that they are where most passengers meet a bottle-neck in the systems and lines form. For this

reason, the following sections discuss the issues as well as the possible root causes.

Airport Check-In

Airport check-in is an unavoidable system no matter what airport customers are flying

out of. These issues have a wide span of reasons. The current airport check-in process in the

United States is slowly becoming more self-serving. "According to IATA, by 2020, 80 percent

of global passengers will use a complete self-service set developed under standards set by the

Association" ("How Airline Industry Streamlines Check-In", 2017). However, currently, many

airports still have the traditional system "which the passenger chooses his seat on the airplane

and delivers (or not) the luggage. The traditional check-in is provided on a counter by an

employee who verifies the ticket, passenger's personal information", (Figure 2 in the appendix

shows the basic operations of the check-in process) (Magalhães, 2014). If the systems are more

advanced the airports use kiosks where you are prompted to type in your reservation number,

swipe a credit card or driver's license, or membership card to find your ticket entry in the

system, follow a few promoted steps on the screen, and then wait for your ticket and baggage tag

to be printed ("Southwest FAQs- Check IN," 2019). For the check-in system in Australia, the

"government launched the Seamless Traveler program, which saw the rollout of biometric

SmartGates at air and sea ports" (Grey,2017). This required passengers to input their passports

into a kiosk and then have a photo taken of them ("SmartGates"). So unlike other countries, the

U.S. system has room for you to lose your ticket, passport or other official documentation, and

then any issues with the kiosk by a user can slow down anyone else.

Airport Baggage

In the United States, the top customer complaints within airports dealt with baggage

issues as well as reservation, ticketing, and boarding issues. In other countries, they do not have

the same issue, some baggage machines can that takes less than 40 seconds instead of the several minutes like traditional baggage drop off with a human. This system then prints out a recipe for the passenger ("Self-service baggage kiosks"). ("US Department of Transportation") (Potgieter, 2017)

In Frankfurt Airport they have a kiosk where passengers scanner their boarding pass, place their bag on a conveyer belt, then attach the baggage tag and approve the removal of their luggage from the kiosk. This system has been in place as several different German airports since as early as 2012. "For unstaffed bag-drop, Frankfurt is also ahead of the curve: here 7% of passengers used the service which is the highest rate recorded in the survey and double the global average" ("Frankfurt Passengers Highest Users," 2013) This number, although it is the highest recorded is incredibly low and leave a lot of room for improvement. Part of the reason self-service is low is because passengers are wary of using mobile devices as an alternative to check-in and for that reason, they opt for the entire check-in/baggage process to be with staffed. ("Frankfurt Passengers Highest Users," 2013)

In the United States, the flier either gets a printed baggage tag when they check in or they get one at the baggage counter. After checking in the customers makes their way to the baggage desk sometimes waiting in line for over an hour just to drop off their bag. At the counter, an airline employee checks the passenger's identification and boarding pass then weighs and tags the bag. The bags are then put on a conveyer belt and travel for miles in the back of airports until they reach their final destination; the plane.

The process is simple but due to the human-to-human interaction, there is a lot of room for additional time added as well as inconsistencies among different employees.

Airport Security

In the United States, the Transportation Security Administration (TSA) is the agency that has authority over any person traveling on an airline. They set the standards and regulations for everything from the amount of liquid a passenger can have in their carry on to the systems used to screen the passengers for anything hidden on their body. This process is done immediately after passengers drop their checked bag off and have an average wait time of about 30 minutes at airports like Altana (Gilbertson, 2019).   ("Security Screening")

When asked, a randomly selected sample of U.S. Adults, what element of their pre-flight experience was most important to them, 79% said that the speed of getting through security was the most important. (Heimlich,2016) In another survey, customers were widely dissatisfied. They complain that the process comes with waiting in long lines, preparation as far as taking shoes off and emptying pockets, and some also find the scanning violating, but it hasn't always been quite like that. The United States airport security system has been dramatically revamped since the terrorist attacks on September 11th, 2001 and most have not been adjusted since this change. This means that the airports can't rely on their old systems security systems as time goes on because of increases in passenger traffic. New systems need to be created to utilize new technology advancements and also create faster systems.

Within United States airport security there are about 500 full-body scanners in use. Two types of scanners exist, the backscatter x-ray scanner and the millimeter-wave based scanner and United States airports have about half of each type. Backscatter scanners use low-doses of ionizing radiation. This scanner is banned in Europe due to the possibility that the radiation could lead to cancer Grabell, 2011). Whereas the millimeter-wave scanner uses radio waves and produces no ionizing radiation. ("Are full-body airport scanners safe," 2011) The millimeter-

wave scanners the passenger and outlines a generic human body with marked locations for

further investigation or a green screen with the word "OK." (Accardo & Chaudhry, 2014)

Emerging Technologies

New technologies are becoming public every day. Generally, these pieces of technology

serve a specific purpose in a specific industry and throughout the lifecycle of the product, there is

not much variation within the industry or purpose in which the product is used. Listed below are

several areas of technology that have not yet been fully introduced into the airport industry but

have the potential to disrupt the current system.

Automated Guided Vehicles

Founded in 2003, the Kiva Systems Inc is a robotic system used for distribution

operations, such as picking up, packing and shipping item. Kiva Systems' name grew after it

was acquired by Amazon in March of 2012. Since then it has been added to distribution centers

for major companies all around the country. Since its birth and rapid growth, the "Kiva Systems"

is already seeking new ways to expand into other distribution sections" (Wulfraat,2019).

These systems work by using the AGV (Automated Guided Vehicles), or the Kiva Devices, to

move shelves around the warehouse to a picker (human) who will take the items off of the shelf

and place it in the customer's box that will be shipped. The AGV's are able to track the items on

each shelf and collect the shelf that has the items. The AGV's use cameras looking upwards and

downwards to help orient themselves with the grids that are mounted on the floor.

Along with the cameras, the AGV's have sensors that help the device detect if obstacles

are in the way. Generally, the only objects that will be obstructing the path is another Kiva. To

help eliminate this issue the "robots receive directions from the MHE-system which runs on a

centralized computer that broadcasts instructions through the wireless network" (Wulfratt,2019).

This allows the computer to tell the AGV's what path to take in order to avoid collisions and

traffic jams. The average speed of an AGV is about 3 mph and so this allows for changes in the

path if needed.

Each AGV can be told up to 1,000lbs, is about 2' by 2.5' by 1' in size and weights about

250 pounds. Given those dimensions, a typical large warehouse has between 500-1,000 robots at

a time. This can cost them up to $15-20 million for the set-up, devices, and periodic battery

replacement.

> The devices run on rechargeable lead-acid batteries that are charged at frequent
>
> intervals ... such that there is no battery change- out process required. The
>
> [AGVs] simply travel to designated charge stations every couple of hours [for] a
>
> 5-minute battery recharge. ... For the purposes of budgeting, assume that at any
>
> time 5 percent of the [AGVs] will be [unavailable] ... [I]t is important to note that
>
> the batteries ... require periodic replacement. For batteries that undergo consistent
>
> daily usage, the typical battery life cycle is in the order of 1.5 to 2 years. **(**Bozer &
>
> Aldarondo, 2017)

This system is also extremely flexible and scalable so new AGV can be added as needed and the

area of transit can be altered. (Wulfraat, 2019)

Biometrics

In reference to emerging technologies, using body parts as a recognition system between

humans and machines is becoming increasingly popular within many different industries and at

many different levels. Now phones use facial recognition to be opened, dining halls use

fingerprints to recognize students, and government entities use scanners to allow only certain

individuals to access private information.

One example of biometrics is the Finger Scanner.

The FingerScanner application follows a server-client paradigm. The client

(which can be executed in a computer, tablets, smartphone and even in a

Raspberry browser) makes requests to the server and this replies to the client. An

administrator controls the system by using a web application that acts as the

client. The server (running in the Raspberry) and implemented with Node.js), is

responsible for managing the overall system, the Raspberry and their components

and the devices attached to the Raspberry (Sapes & Solsona, 2016).

In simple terms, this FingerScanner is using the client's finger as a password. As soon as

it is scanned the summer sends a request to verify that the fingerprint is in the system. If it is,

then the action is continued, if not then the user is stopped. To top it all off, this all happens

almost instantaneously.

This can also be done with scanning someone's face by looking for key things, such as

distance between facial features, eye color/patterns, and facial expressions. The main idea with

using a persons' biometrics, as opposed to a password, is that these systems cannot be replicated,

guessed, or hacked as easily as a standard 8-character password. The direct user has to be the one

making contact with the scanner to have their information accessed. This can reduce many

security issues that come with systems that can be accessed by anyone who has the right

information. ("Automated Fingerprint Identification System")

Beyond identification biometrics are also being used for border control, voter registration, E-Passports, Healthcare &Welfare, as well as public safety. For border control biometrics is used to have scanned and verified ePassorts and visas, check and log border crossing activities and flag individuals. The process is multi-lingual, had high powered searching capabilities, and has Hi-Speed data searching capabilities. These are currently being used in airports today by scanning a fingerprint, palm print, iris, facial, finger vein, and palm-vein authentication("Automated Fingerprint Identification System"). It is used for public safety by law enforcement. They can manage cases, do criminal booking, use it for analysis, and much more. In each area of use, biometrics has a unique set of traits that the controller can manipulate in order to use the technology in a way that is most beneficial. ("Automated Fingerprint Identification System")

X-Ray Scanners

The first x-ray scanner was created in 1895 by William Conrad Roentgen. His first film was of his wife's hand. Since then this technology has come a very long way. Doctors are able to see in the human body, border patrol are able to scan through a semi-truck, and TSA is able to look at a carry-on bag without opening it up as well as scan a passenger's body for any hidden items.
(Figueras, 2013) PDF of x-ray technology

Other airports within the world, such as Singapore's Changi Airport, are introducing new x-ray technologies. Changi has a system that will flag items that officers need to be checked on the body to avoid unnecessary full-body check and it also displays a stick-man image of the passenger instead of an anatomically correct image in order to ensure the privacy of the

passengers (Lee, 2016). Changi is also testing new body scanners that do not require passengers

to remove any items (?) from their body in order to complete the scans.

Methods

This study primarily required secondary data research. The data I collected was from

scholarly reports, journals, and articles as well as some customer reviews and feedback posted on

various websites. The scholarly data sources were used to support and answer the questions

about how the airports operate, different processes that consist of customer interactions, and

where pain points, as well as emerging technologies within different industries that could be used

to replace current systems. Data from secondary sources were found from places like the UNH

Library Database and Google Scholar. The data was collected through readings and analysis of

studies.

Results

The following sections will explore possible solutions for each of the problem areas

within United States airports discussed earlier. Each solution will tie in the use of emerging

technology with the hopes of completely disrupting the existing airport systems.

Check-in Area

As previously discussed, the Check-in areas within the airport are considered a pain point

for customers. The idea is to use a biometric system in order to check passengers in. This system

would require passengers to continue the traditional process of scanning their identification,

either a passport or driver's license and select their flight. However, it adds a step of also

scanning the passenger's fingerprint or using facial recognition.

This scan will replace the need for a boarding pass or identification to be used during

other processes in the airport. Passengers will scan their finger before going into TSA and scan

their finger before boarding the plan. All the information will be stored within the fingerprint.

Biometric works like a passport, it can be used to open files or grant access. So, at TSA

the fingerprint would be used to verify that the person is actually a passenger and the same for

boarding the plane.

Another thing that will happen during check-in is the passenger will be issued a baggage

tag with a small computerized chip in it. This is be used later on during baggage drop off.

In the end goal with a more self-automated system and using biometrics is to help reduce

lines as well as helping with security measures. Although this process will add time due to the

additional scan, the added time will only be about 30 seconds at most per person. The time saved

will be in other stages.

Baggage Drop Off

Baggage drop is an area of the airport that can also be self-service. If there was a

computer chip within the baggage tag that is printed out at check-in then there would be no need

for a drop off counter. The idea is that passengers will put their bags, with the tag, onto a

conveyer belt, similar to when a bag is picked up after a flight, but it will be going the other way.

For the passenger, they will be saved time in line because of this process is instantaneous.

The bags will be brought to a lower level where they will be greeted by an adapted

Amazon Kiva. Once placed on the Kiva, the sensors within the AGV will determine where the

bag needs to go and the weight of the bag. The weight will be sent to another computer which

will then charge the passenger if it is over the allotted limit.

This would replace the current system of using a conveyer belt. On average a conveyer belt can deliver 700.71 items per hour and a trivial/storage like Kiva can deliver 712.83 items per hour (ISE Magazine). Although this does not seem like a drastic difference this change in system eliminates the need for a check-in employee and therefore eliminates the human-error when it comes to lost baggage.

Unlike the conveyer-belt, this system can also be adapted for a larger through-put much easier than the conveyer-belt(ISE Magazine). To keep up with the growing travel industry more Kiva's could be added as needed.

Currently, the largest commercial plane capacity for United States domestic flights is about 525 on an Airbus A38. So, there would have to be enough AGV's within the system to keep up with the busiest times and days within an airport. Ideally, there would be enough for each bag to be met by a Kiva immediately as to not reach a hold-up.

Security

The last section that will be discussed is in reference to changing the TSA. Currently, the United States has the technology to scan semi-trucks, human organs and everything in between. The goal is to use these technologies to come up with a system that does not require customers to take off any clothing, shoes, or empty their carry-ons.

The passenger would begin by scanning their finger and then walking through the body-scanner. The results would be almost immediately so that on the other end of the body- scanner the passenger would be greeted by a red or green light. The red light would require a member of TSA to scan the person in a more traditional manner and search their bag, however, they would be brought to the side so that other passengers could continue to make through way through TSA, avoiding lines. Similar to the baggage system this process will be faster and also help avoid

the creation of lines. The passengers will be walking through and because results are almost immediate the crowds will be able to keep moving through. There is a possibility for there to be a lineup of passengers who do not pass the scan if TSA does not search the passengers quickly. However, the goal if for TSA to look at the scan, identify the problem area and investigate, while still keeping the process until a minute.

All in all, if the systems operate efficiently then suggested arrival time of 2 hours before a flight boarding time can be reduced to 30-45 minutes before. This would give passengers time to get through check-in, drop off bags, and make it through TSA as well as give the bags time to make it to their allotted plane loading area.

Future Areas of Research

The following sections will briefly discuss areas of future exploration that were well beyond the scope of this project. These are areas that the author was aware of but was unable to address due to timing and lack of basic knowledge within through areas.

Security Measures

When changing any system that required the collection of personal information, especially when that information is also in the form of government documents and biometric scans, it is important to have a secure system. There are rules and regulations that determine what businesses can and can't do when storing, evaluating, and storing. It can be very easy to break this privacy regulation simply by being unaware of them. For this reason, it would be important for a privacy professional to look at the system changes and verify that they are compliant.

Engineering Focus

This research was not done by an engineer and for that reason, it is important to note that the proposed solutions would need to be assessed in a more technical light. The physical design and flow of the system, as well as the communication between pieces of technology, are essential for these solutions to be effective. So, it will be crucial to have experienced professionals look at the system.

Resistance by Users/Customers

The user, or customer, is a very important stakeholder in this proposal. They are the main reason for changing the system since the customers are standing in line for hours and have to deal with each part of the stated problem areas. Although it might seem like all customers will be on board with a new system that should save them time and energy; There will be some customers who are resistant to change, like frequent flyers who are used to current systems and have pre-check, or older people who prefer talking with people over the use of this equipment. Noting this will be important in the transition. There will need to be employees nearby so that the users have someone to fall back on if they feel like a mistake has been made.

Implementing the Vision

Changing an existing system can be difficult especially when the operations cannot just be shut off for a period of time. These proposed changes will need to be gradual so as to not disrupt the airport operations. There will have to be several different installment phases for each section. For the check-in kiosks workers will remove old systems and install new ones a couple at a time so that not too many systems are offline. This will be the same as the other systems

within the airport. Throughout this period customers can expect longer waits however sometimes that is needed to make improvements.

Next Steps for Airports [5]

Since the infrastructure of United States airports is aging and passenger traffic is increasing, drastic measures should be taken to decrease wait times or even just keep them constants. Airports interested in updating and improving their systems should begin to assess their needs and look into what technologies exist, not only within the industry but also outside of their specific industry. Professionals should look into what technologies can be modified to fit the needs of airports to solve the issue of increasing passenger traffic and wait times.

The solutions discussed in this thesis would be effective in the smaller to medium-sized commercial airports. This is because the baggage system within a larger airport might need more space than is currently in use for more Kiva's. There are parts of this that could be implemented within a larger airport, like the security system that customers can just walk through.

All in all, the idea is to look outside of the traditional industry lens and find solutions that need some adaptation but could provide a more effective solution. Professionals within the field should be constantly looking to upgrade to modernize airports and make them more efficient. In the end, the goal is to make airport systems faster, safer, and easier for all stakeholders involved.

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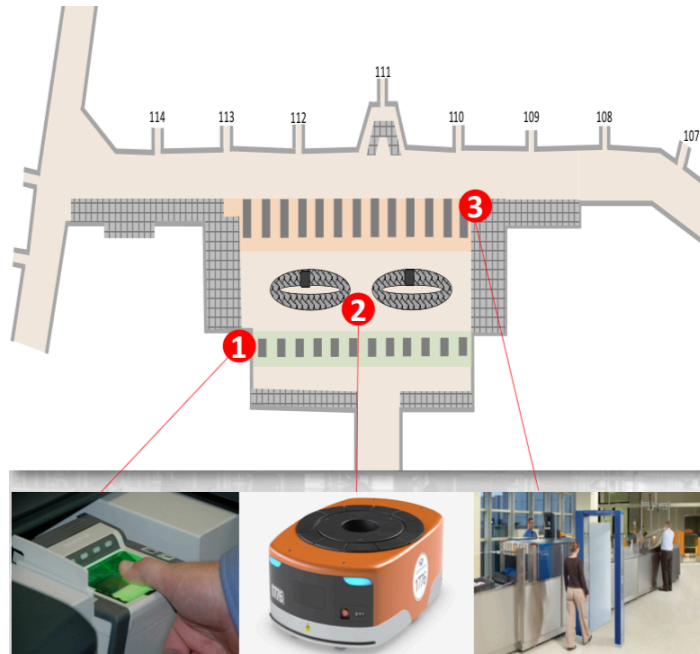
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Appendix

Figure 1:

Figure 2: (Magalhães,2014)