Short-Wait Integrated Flight Travel (SWIFT) System

Applying Policy Changes, Technological Innovations, and Process Enhancements to Improve Airport Security and Efficiency

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EXECUTIVE SUMMARY

The tragic events of September 11, 2001 created an immediate and urgent demand for a major overhaul in airport security, particularly the passenger screening process. The urgency of the response has given rise to an extremely rapid build-up of the Transportation Security Administration (TSA) to a staffing level of 55,600 screeners at the nation’s airports. There has been considerable criticism of the current security system, partly because of the occasional long delays, partly because of demonstrably low-risk individuals (e.g., elderly women) being subjected to intense scrutiny, and partly because of the over-staffing at various screening stations.

The SWIFT (Short-Wait Integrated Flight Travel) System represents an initiative by Carnegie Mellon University’s H. John Heinz III School of Public Policy and Management to design an airport security system that is both more secure and more efficient. With SWIFT, travelers who volunteer to submit to a security clearance by TSA and pass will receive a “smart card” containing personal and biometric information. SWIFT enrollees will be able to go through a security screening comparable to that which was used prior to September 11, 2001. By screening SWIFT enrollees prior to their arrival at an airport, TSA can focus its resources on more thorough screening of not-cleared individuals. Our research focused on estimating the demand for SWIFT enrollment, design of a reasonable system that included biometric screening of all those carrying a SWIFT card, review of current technological opportunities for screening SWIFT passengers, initial design of a national SWIFT network, identifying processing enhancements of the current system, analyzing costs and benefits of the various improvements through the use of simulation modeling, and designing an initial test implementation of the SWIFT System at the Pittsburgh International Airport (PIT). The results of this research hold promise for creating an airport security system that is markedly more secure and more efficient than the current one.

We have estimated the demand for SWIFT through use of a series of surveys intended to assess how much passengers are willing to pay and their trade-off between convenience, privacy and time savings. A face-to-face survey was used to elicit commercial air travel habits of arriving passengers at the Pittsburgh International Airport (PIT). We also used the results of a telephone survey conducted by the Air Transport Association (ATA) that was administered to approximately 4,000
travelers. Both survey analyses estimated that on any given day, roughly 40% of all travelers would be SWIFT enrollees. Some other major survey findings are as follows:

- Waiting in lines at security checkpoints and the hassle of the passenger screening process, and the cost of plane tickets were the three most important concerns passengers identified with air travel
- Because of uncertainties in anticipated delays, passengers arrival, on average, 30-60 minutes earlier for flights today than before September 11, 2001
- Passengers at Pittsburgh International Airport indicated a willingness to pay $50 for enrollment in a registered traveler program

We calculated the time-cost of delay per traveler (the opportunity cost the passenger incurs while waiting to board a flight) using an average weighted annual salary of $75,000, and assuming the opportunity cost amounts to 50% of the passenger’s salary, at $18 dollars per roundtrip. We found that this time-cost of delay totals about $5 billion for the U.S. This delay is especially significant for frequent travelers and has been one important factor in the reduced demand for air travel.

An important part of SWIFT are the biometric technologies used to ensure that the person using the card is the one to whom it was issued. An enrollee’s biometric profile, along with a digital photo and signature and other personal information, would then be loaded onto a 32 KB identification card to verify that individual’s identity at the airport security checkpoint. Criteria for choosing biometric technology alternatives include resistance to false acceptance, resistance to environmental factors, stability, interoperability with existing derogatory databases, and vendor support. Finger scans and iris scans currently represent the most attractive biometric technologies for use in the SWIFT System. Each meets our stringent false-acceptance criteria and a fused system composed of these two biometric devices has a low false-rejection rate of less than 3 in 10,000.

Enrollment in the SWIFT System is strictly voluntary, and the TSA will have to decide the bases for SWIFT eligibility or rejection what national databases will be searched. Potential information that might be used could include past countries of residence, criminal records, credit history, employment history, and foreign travel history. Applicants who already have been granted security clearances by the United States government or military would be easy to assess. In order to make enrollment for the SWIFT System accessible to its target market of frequent business travelers, we
designed enrollment centers to be located within secure sections of participating airports. The SWIFT application form also could be designed so that an individual can complete it while waiting at an airport, during a flight, or while at home. Enrollment centers will capture the biometric information of the applicant as well as renew old cards.

We were also asked by the Allegheny County Airport Authority to analyze baggage and passenger screening. We have produced some suggestions for improving the efficiency of the current system:

• For checkpoint processing, we found that the x-ray inspection of bags took appreciably longer than magnetometer testing, and so this suggests increasing the number of x-ray stations per magnetometer. Using an Arena simulation, we found that installing two x-rays per magnetometer would reduce average delay by 40%.

• Faster processing of the SWIFT travelers, reduces the delay to all travelers. We also found that by adjusting the sensitivity of the magnetometer for SWIFT travelers, we can increase throughput.

• A policy that adjusts the sensitivity of the walk-through metal detectors and allows SWIFT members a ‘second pass’ would decrease delay because it reduces the rate of secondary screenings and associated “wandings.” Simulation software was particularly helpful in assessing the savings associated with those changes. Such analyses would also be applicable at other airports.

• For CTX baggage screening, about 22% of bags create an alarm and then occupy the x-ray machine for considerable time while the appropriate response is decided on. A shunt moving the bag onto an “alarm-bag conveyor” with a remote video showing the alarm condition could increase the CTX processing rate by about 50%.

We find the benefits associated with SWIFT to be sufficiently attractive that we recommend initial testing of a SWIFT System at Pittsburgh International Airport (PIT), to be followed by similar testing at several other airports. Initially, all that will be needed at the airport checkpoint will be a card scanner and biometric devices, and those are likely to be in place for employees using the Transportation Worker Identification Card (TWIC). The initial SWIFT users will be airport and airline employees, followed by airlines’ preferred passengers, who will be issued the cards at no cost. Later versions of the SWIFT System will involve identifying the SWIFT travelers by the airline at
check-in and having their baggage scanned in a priority mode. Eventually, a network configuration will tie together a national database of SWIFT travelers and their biometric information. The information contained within this network will receive regular updates by TSA and other national security agencies.
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The United States government, the airline industry, and the traveling public share the need for a secure air transportation infrastructure. Prior to the tragic events of September 11, 2001, commercial flights were considered a cost- and time-effective means of travel between even relatively close destinations. The pre-flight processing and wait time at airports was relatively brief and predictable. The major commercial airlines advised domestic passengers to arrive at airports at least one hour prior to a flight’s departure, and the nation’s airport security measures consisted largely of checking a passenger’s photo identification, a magnetometer screening of the passengers, and an x-ray of carry-on items. These security measures were handled by the airlines and privately-contracted security firms. The commercial airline industry had enjoyed more than a decade of profitable operation prior to September 11th and future growth was expected.

The events of September 11th altered the future course of air travel in the United States when the hijacking of four commercial flights demonstrated the need for a security system that would provide a more thorough and intense scrutiny of individual passengers and their baggage. In response to that need, Congress created the Transportation Security Administration (TSA) in November of 2001 with a mission to “protect the Nation's transportation systems to ensure freedom of movement for people and commerce.”¹ In its hurry to safeguard air travel, the newly-created agency federalized airport security, hired more than 55,000 airport security screeners, and introduced security procedures that were more thorough and intense, and thus entailed greater time and expense.² The new security measures include more sensitive magnetometer screenings, more thorough x-ray screenings of carry-on items, computed tomography x-ray (CTX) and/or explosive trace detection (ETD) screenings of all checked

baggage, manual searches of select carry-on baggage, tests for explosives residue on the shoes of select passengers, and other less-visible security process enhancements.

Although TSA’s decisions are based foremost on the security implications of those decisions, it is worth noting that there are significant costs associated with TSA’s new security measures. First, there is a direct cost incurred from the hiring of more than 55,000 security screeners and the cost of the new security equipment. The TSA’s budget in its first year of existence amounted to $5.3 billion, of which most was dedicated towards airport security. Second, there is also a cost in terms of the loss of time among the traveling public, which is subjected to the increased time and hassle associated with airport security. This is a more difficult cost to measure than the direct costs of airport security listed in TSA budget, but may be more significant. As a result of the higher mean delay and higher amount of variance associated with the risk of missing a flight due to the more intense security processes, passengers arrive at airports earlier now than before September 11, 2001. It is reasonable to estimate the annual cost to the nation of a half-hour delay at approximately $5 billion. The increase in delay is supported by TSA’s and the airlines’ recommendation post-September 11th for passengers to arrive at an airport between one-and-a-half to two-and-a-half hours prior to a domestic flight's scheduled departure time. Faced with increases in time, cost, and hassle that are associated with the movement towards a more secure environment, individuals who previously flew on relatively short routes between cities characterized with high time elasticity of demand choose to drive. This marked drop in passenger volume on high-margin, short-haul flights contributes directly to the declining profitability of American commercial carriers including American Airlines, United Airlines, and especially U.S. Airways with its short route structure.

A team of nine graduate students under the direction of faculty advisor Dr. Alfred Blumstein at the H. John Heinz III School of Public Policy and Management at Carnegie Mellon University has designed the SWIFT (Short-Wait Integrated Flight Travel) System as a means to reduce the

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4 Assume that people value their time at half their income; the mean income of air travelers is $60,000; and 600 million flights are taken annually by individuals in the US; therefore 600,000,000 x $15/hour x 0.5 = $4.5 billion.
5 See Table A.2 in Appendix A for a listing of the greatest distances passengers will choose to drive instead of fly.
delay, hassle, and cost associated with problems encountered in securing the nation’s air transportation system. The SWIFT System’s design is largely based on the following facts:

1. The vast majority of travelers pose no security threat
2. Most of this nation’s 600 million annual trips are made by a disproportionately small percentage of travelers
3. Approximately 40% of travelers on any given day have indicated that they would be willing to submit to a voluntary background check, provide personal biometric information, and pay $50 in order to obtain SWIFT clearance.

Passengers enrolled in the SWIFT System must pass a background check and provide biometric information. SWIFT enrollees could then arrive at a participating airport according to the pre-September 11th recommendations (approximately one hour), submit to biometric identity verification, and pass through a more streamlined security check comparable to pre-September 11th security. TSA resources that had been spent on subjecting all passengers to the same intensity of screening could then be re-directed to screening those individuals who more likely pose security threats. The idea is frequently thought of as “reducing the size of the haystack in searching for the needles” in order to bring greater scrutiny to those individuals who pose the greatest risk. Other less tangible but important benefits include encouraging individuals to fly between destinations that have a relatively high elasticity of demand rather than drive (a statistically more dangerous means of travel) and minimizing the amount of wasted productive time that individuals spend at the airport and would otherwise contribute to the nation’s economy. Finally, it is important to note that enrollment in the SWIFT System is strictly voluntary, and thus avoids the concern over invasions of privacy that have been raised over CAPPS II screening. Instead, the SWIFT System is designed to respect civil liberties by having a strictly voluntary enrollment policy.

The SWIFT System meets the TSA demands for enhanced security, improved commerce, and protection of personal privacy. In developing the system, input has been gathered from the major stakeholders including TSA, Allegheny County Airport Authority, US Airways, and the traveling public. Demand for the SWIFT System has been confirmed through a survey conducted among passengers at Pittsburgh International Airport. The costs to the airlines and the aggregated cost to travelers as a function of time saved and reduce staffing needs under the

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6 See Chart 1 for an estimate of SWIFT enrollees based on trip frequency.
current system versus the proposed SWIFT System have been estimated. The various processes and technical components that will comprise the SWIFT System have been evaluated, and recommendations are contained within the report. Processing enhancements to the individual security checkpoint and checked-baggage screening systems have been designed, simulated, and the results are contained within the report. A pilot SWIFT System test has also been designed for Pittsburgh International Airport, but it is expandable to other airports, and includes biometric technologies, network designs, and testing configurations.
VALUE PROPOSITION

A system that decreases passengers’ time spent at the airport, perceived hassle of airport security screening and the cost of airport security, while maintaining or increasing the current level of security, will generate benefit to all relevant stakeholders.

Passengers

The recent changes in airport security have led to a significant increase in the average amount of time air travelers spend undergoing security screening. Most passengers, however, do not calculate their airport arrival time based on the average time it takes to pass through security. Rather, to minimize the risk of missing their flights, passengers calculate their airport arrival time based on the equivalent of the worst-case security delay. Because recent changes in security measures have resulted in an increase in the variance of delay times, passengers must leave even more time before their departures to avoid missing their flights. A system that reduces both the mean and the variance of the airport security waiting time would generate value for passengers by allowing them to save valuable time.

Increased airport security measures have cost significant taxpayer dollars. Aviation security is budgeted to account for $4.22 billion of the $4.82 billion allocated to TSA in the Bush Administration’s 2004 budget. In order to defray some of these costs, TSA has implemented two congressionally legislated security fees. These fees are collected from passengers by means of additional taxes on their airline tickets. A system that reduces the cost of airport security would permit passengers to fly less expensively.

For some passengers, airport security screening can feel intrusive and irritating. Allowing passengers to undergo less invasive processing would help alleviate this perception.

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Airlines
Because flying now takes longer than it did, and because it is more expensive and intrusive, some passengers will choose alternative modes of transportation, such as car or train, especially for short trips. The loss of customers is especially damaging to the airlines in the current distressed financial environment. A system that lowers the price of security, passenger wait-time and perceived ‘hassle’ will benefit the airlines through increased passenger demand.

TSA
The TSA’s primary objective is to safeguard the security of the traveling American public. Therefore, any system that will satisfy all major stakeholders must provide protection equal or superior to what is already in place. A system that enables the re-allocation of security resources from passengers who have been determined to pose low risk, to those whose risk has not been determined, will ultimately result in higher security.
DEMAND ESTIMATION

The public’s demand for a more secure and more efficient air transportation system justifies the implementation of a SWIFT System.\(^8\) It is critical to assess passengers’ willingness to pay, as well as what amount of trade-off between convenience, privacy and time-savings passengers will accept. This section attempts to answer those questions by analyzing data from a passenger survey administered at the Pittsburgh International Airport in March 2003 and a telephone survey administered by the Air Transport Association in 2002.\(^9\)

**Purpose of the Survey**

Determining passenger interest in a registered traveler program was essential to moving forward with this project. Quantitative analyses allows decision makers to better estimate passenger enrollment based on how much passengers are willing to pay for such a program and how frequently they travel. Moreover, the costs and potential benefits of such a system can be incorporated into the overall analysis.

An important component of the demand estimation for a registered traveler program is understanding the distribution of how often passengers travel.\(^10\) Knowing which passengers travel most frequently allows us to understand which market segments will benefit most from the SWIFT System. Based on the survey results, roughly 48% of air travelers surveyed flew commercially 10 times or more per year.\(^11\)

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\(^8\) “SWIFT System” and “Registered Traveler program” are used interchangeably here.

\(^9\) A face-to-face survey was used to elicit commercial air travel habits of 144 individuals at the Pittsburgh International Airport (PIT) from March 7 to March 20, 2003.\(^9\) An analysis of the PIT survey results was used to gauge passenger travel habits, passenger views on certain airport processes, and passengers’ willingness-to-pay to participate in a registered traveler program that would reduce the overall waiting time at the airport while enhancing security. Passenger responses were then used to estimate demand at various prices for a registered traveler program based on passenger travel frequency and how much passengers stated they were willing to pay for enrollment in such a program. See Figure A.1 in the Appendix to view a copy of the PIT survey.

\(^10\) See Chart A.1 in the Appendix.

\(^11\) The Air Transport Association (ATA) collected survey data on passenger travel habits and their findings offer a nice comparison to the findings here. Specifically, ATA found that roughly 90 percent of all air travelers surveyed flew commercially less than 10 times per year. Several factors may be responsible for this disparity. ATA randomly sampled 4,098 air travelers by telephone, while convenience sampling in person was used to collect our survey data. Additionally, the SWIFT survey data collection was done during the peak hours of 7:00 AM to 9:00 AM and 3:00 PM to 5:00 PM (Monday thru Friday), and consequently, the sample is weighted more heavily by frequent travelers.
In determining the SWIFT target market, it is useful to measure passenger interest based on air travel frequency. As might be expected, the analyses reveal that the more often a passenger flies, the more likely he is to be interested in a registered traveler program. In fact, passengers traveling 10 or more times per year were significantly more likely to express interest in a registered traveler program compared to those passengers traveling only one time per year. In addition, 89% of passengers who flew more than five times per year displayed interest in a registered traveler program while only 79% of passengers flying less than five times per year expressed interest in a registered traveler program. This supports the finding that the more often one flies, the more likely they are to be enrolled in SWIFT—this is an important distinction when marketing the program and is further discussed in the elasticity section.

The chart below is based on PIT survey results. The light bars represent the proportion of travelers on a given day based on trip frequency and the dark bars estimate the percentage of those passengers who would be willing to pay (WTP) $50 to be SWIFT enrollees.

**Chart 1: Estimate of SWIFT Enrollees Based on Trip Frequency**

<table>
<thead>
<tr>
<th># of trips in the past year</th>
<th>Proportion of Flyers</th>
<th>SWIFT Enrollees WTP $50</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>3-4</td>
<td>16%</td>
<td>2%</td>
</tr>
<tr>
<td>5-9</td>
<td>19%</td>
<td>6%</td>
</tr>
<tr>
<td>10+</td>
<td>48%</td>
<td>29%</td>
</tr>
</tbody>
</table>

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12 See ChartA.2 in the Appendix.
13 Passengers flying more than five times per year account for approximately 67% of the sample.
Then, of those passengers willing to pay $50 for enrollment, we determined that about 40% of all trips would be made by registered travelers.\textsuperscript{14} We find similar results when we compare the results of the PIT survey analysis to estimates calculated using the ATA survey. From our analysis of the ATA survey data, we estimated that, on any given day, roughly 36% of all flights would be made by registered travelers. We find very similar results when looking at the PIT survey results. In fact, approximately 38% of all flights on a given day would be made by SWIFT enrollees. This is represented by the sum total of the dark SWIFT enrollee bars in Chart 1. These findings are encouraging because we have similar results pertaining to the viability of the SWIFT System from two different data sources.

**Time Cost of Delay**

Time cost of delay (TCD) is the opportunity cost that passengers incur while waiting to board flights. For the purposes of this paper, TCD is defined as the additional time (relative to pre-September 11\textsuperscript{th} delays) that a passenger is at an airport prior to departure multiplied by a fraction of his salary. According to the ATA survey data, the weighted average salary of air travelers is estimated to be between $75,000 and $99,000.\textsuperscript{15} Using data from the PIT survey, we find that passengers arrived at the airport about one hour before their departure time prior to September 11, 2001. Today, the average passenger arrives roughly two hours before his departure time – meaning that, on average, passengers are arriving at Pittsburgh International Airport about one hour earlier than they did prior to September 11, 2001.

Using the survey results we estimate the TCD by multiplying some fraction of the average passenger’s salary by the average *marginal* processing time spent at the airport prior to departure.\textsuperscript{16, 17} Therefore, if the average weighted salary is estimated to be $75,000 and the

\textsuperscript{14} 40% is the sum of all passengers interested and willing to pay $50. Add up those individuals traveling twice yearly (1%), 3-4 times per year (2%), 5-9 times per year (6%) and 10+ times (29%) and it gives roughly 40%.

\textsuperscript{15} See Table A.1 in the Appendix for the travel frequency by salary at PIT.

\textsuperscript{16} 50% of salary is often used in the time cost of travel literature although there is disagreement on this point in the prevailing literature. In a 1996 survey, Miller recommends using 55% of the wage rate for drivers (all trip purposes) and 40% for passengers, whether in autos or transit vehicles (Miller, 1996). On the other hand, the U.S. DOT guidance on travel time recommends 50% of the wage rate for both drivers and passengers. While there is no consensus on this issue, it is logical that the stresses of driving may make travel time savings more important to drivers than to passengers. Unfortunately, the extent of these differences is not well established and should be put aside until they are better researched [Source: "California Life-Cycle Benefit/Cost Analysis Model", Booz, Allen & Hamilton, 1999].
hourly rate of the passenger’s opportunity cost amounts to 50% of his salary, then arriving at the
airport two hours before departure (thus waiting an additional hour) equates to $18 per passenger
per roundtrip.\textsuperscript{18} If the average business traveler makes 20 roundtrips per year and has an annual
salary of $75,000, he incurs an annual TCD of $720. As a result of this high TCD, more
travelers are more likely to choose other means of transportation, e.g. automobile or train.\textsuperscript{19} The
survey results suggest that more than one quarter of the individuals flying 10 or more times per
year would choose to drive distances of 300 miles or less instead of flying commercially.\textsuperscript{20}

The implication is that frequent travelers, and especially frequent business travelers, highly value
their time. By reducing the current waiting time at the airport, it is likely that air travel will
increase by some proportion of travelers now willing to substitute driving short distances (300
miles or less) for flying commercially. This fact is particularly applicable to short business
flights from Pittsburgh to Washington, D.C., or from Boston to New York. As TCD decreases,
more travelers will opt to fly commercially instead of driving or taking the train. Thus, reducing
wait time is a critical component when discussing the potential demand for a registered traveler
program.

**Estimated Elasticity of Demand**

Elasticity of demand is an economic concept that measures the effect of a one percent change in
price on the percentage change in consumption. In terms of passenger enrollment in a registered
traveler program, the demand elasticity can be defined as the effect of a one percentage increase
or decrease in the cost of enrollment on the percentage of travelers that actually enroll. Elasticity
estimates help to predict how passengers will respond to a change in the price for enrollment in a
registered traveler program.\textsuperscript{21}

\textsuperscript{17} The average marginal processing time refers to the additional time spent waiting at the airport today when
compared to previous passenger wait times (pre-September 11, 2001).
\textsuperscript{18} 50% of the average salary of $75,000 is $18 per hour. For an additional hour of waiting (the difference of two
hours wait time today and one hour wait time pre-September 11, 2001 leaves one additional hour of waiting) this
works out to $36 per passenger per roundtrip.
\textsuperscript{19} Even that alternative has a ceiling. For instance, some individuals will choose to fly no matter their TCD.
\textsuperscript{20} See Table A.2 in the Appendix for the greatest distance passengers would choose to drive instead of fly.
\textsuperscript{21} The PIT survey gave respondents six choices when deciding how much they would be willing to pay to enroll in a
registered traveler system: $0, $25, $50, $75, $100 or $150. Their responses permit estimation of passenger enrollment as a function of price.
The PIT survey asked passengers if they would be interested in enrolling in a registered traveler program if it reduced the waiting time at the airport.\textsuperscript{22} Overall, 86\% of respondents indicated that they would be interested in such a program, while 91\% of passengers flying more than 10 times per year expressed interest in the program. Passengers indicated the average time savings associated with a registered traveler program should be roughly 30 minutes to one hour—the average difference in passenger wait time today as compared to pre-September 11 wait times. Finally, passengers were asked what was the most they would pay to enroll in a program that reduced their current wait times.\textsuperscript{23} These responses were used to estimate the elasticity of demand for enrollment in a registered traveler program.\textsuperscript{24}

The analyses estimated the elasticity of demand for enrollment in a registered traveler program for all respondents to be –1.5. The interpretation is that a one percent increase in the price of enrollment in a registered traveler program leads to a 1.5\% decrease in actual enrollment. Passengers traveling less than five times per year had an estimated demand elasticity of –1.8. In other words, a one percent increase in the price of enrollment leads to a 1.8\% decrease in actual enrollment. Passengers who make ten or more trips per year have an estimated elasticity of demand of -1.3. Thus, a one percent increase in the price of enrollment will lead to a 1.3\% decrease in actual enrollment of those passengers.

Understandably, the elasticity of demand for frequent travelers is less (in absolute terms) than for infrequent travelers. This may result from the fact that a greater proportion of business persons must travel, and as a result, are less affected by the price of enrollment in a registered traveler program than infrequent travelers who often travel for leisure rather than business. Moreover, TCD is more closely associated with business travel, and consequently, business travelers are more likely to be less affected by a change in price than less frequent, non-business travelers.

\textsuperscript{22} See Table A.3 in the Appendix for passengers’ willingness-to-pay by travel frequency.
\textsuperscript{23} Specifically, if passengers said they were interested in the program they could choose to pay: $0, $25, $50, $75, $100 or $150 to enroll. In conjunction with passenger travel frequency, these values were used to estimate the elasticity of demand for enrollment in a registered traveler program similar to a SWIFT System.
\textsuperscript{24} It is important to note that asking respondents to estimate what they would pay for an unfamiliar service (and one that has yet to be implemented) can create imprecise results. A more precise survey instrument that explicitly describes the specific registered traveler program being considered would provide better data.
Summary of Findings on Demand

This section has looked at the results from the PIT passenger survey and estimated passenger travel frequencies, the time cost of delay as well as the elasticity of demand associated with the price of enrollment in a registered traveler program. The main findings of the demand analysis are summarized as follows:

- Based on the PIT and ATA survey analyses, air travelers want to reduce the marginal time spent waiting at the airport, while enhancing security. Moreover, the majority of these air travelers are willing to pay for this service.

- Based on the PIT survey results, if enrollment reduced wait time at the airport by approximately 30 minutes, roughly 40% of all travelers, on a given day, would be registered travelers at a price of $50. This implies that for the registered traveler program to be effective it must be both affordable (to encourage initial participation) and, more importantly, time saving.\(^{25}\)

- PIT survey results were compared to ATA survey results and the findings were very similar. In fact both data sources estimate that on any given day approximately 35%-40% of all travelers will be registered traveler participants.

- The results suggest that decreasing the current wait time to pre-September 11\(^{th}\) levels would encourage more travelers to fly commercially instead of using alternative means of transportation. By getting passengers to their terminals more quickly, more revenue will be realized through an increase in passenger demand.\(^{26}\)

- Additionally, the price elasticity of demand was estimated by passenger travel frequency and, based on the survey sample, a one percent change in price results in a greater than one percent change in enrollment (based on passenger travel frequency). Infrequent travelers are

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\(^{25}\) Based on the PIT survey results, those passengers traveling more than 10 times per year arrive at the airport significantly later (prior to their scheduled departure) than infrequent travelers. Again, this points to TCD as it relates to business travel.

\(^{26}\) By how much revenues will increase was not discussed here. However, it is an important question that should be addressed in future research.
more sensitive to price changes than were frequent travelers, thus, suggesting that business travelers have less flexibility in terms of costs and waiting time (TCD).

These findings lend support to the implementation of a registered traveler program. However, there are many variables that were not considered here. We have said nothing about the trade-off between privacy and enhanced safety often discussed in the post-September 11th world. A study conducted by W. Kip Viscusi and Richard J. Zeckhauser of Harvard Law School found that respondents indicated a willingness to tradeoff privacy concerns, especially when there were significant efficiency gains in terms of reduced waiting time.\footnote{Viscusi, W. Kip, and Richard J. Zeckhauser. “Sacrificing Civil Liberties to Reduce Terrorism Risks,” Harvard Law School: John M. Olin Center for Law, Economics, and Business, Discussion Paper # 401. \url{http://www.law.harvard.edu/programs/olin_center/} (January 2003).}
FUNCTIONAL SYSTEM DESIGN

Now that the demand for the SWIFT System has been demonstrated, the major functional requirements of the system must be established. These are separated into three linked systems: (1.) Enrollment, (2.) Airport, and (3.) On-going (see Figure 1 on next page). While the SWIFT System is designed to drive benefit at the airport security checkpoint, certain aspects of the airport system require prior activity. For this reason, a complete system design must include “enrollment” functionality, as well as the “airport” functions that will occur at the security checkpoint. Additionally, the needs of a third system, which we will call “on-going,” must also be defined. The on-going needs are those that will permit the system goals to continue to be met over time and as external factors change.

In this section, the functional requirements of the three systems (enrollment, airport, and on-going) are defined. The enrollment system describes the application and clearance process that must precede any activities that will take place at the airport. The enrollment system requires a single expert per system participant. The “airport” system describes the efficiency improvements that will occur at airports. The airport system improves airport efficiencies and is repeated each time a SWIFT enrollee uses a participating airport. The on-going system functionalities ensures that the SWIFT System will continue to function efficiently and with integrity over time. The on-going functionalities may occur several times over a traveler’s enrollment span, but are not expected to occur frequently.
**Figure 1: System Functional Requirements**

1. **Enrollment**

- Solicit SWIFT System Application
- Obtain and Submit Application
- Verify Applicant Low Risk
- Certify Applicant as System Participant

2. **Airport (Security Checkpoint)**

- Verify Passenger is SWIFT System Enrollee
- Verify Enrollee’s Identity
- Verify Enrollee Scheduled to Fly
- Reconfirm that Enrollee Poses Low Risk
- Enrollee Undergoes Expedited Processing

3. **On-Going**

- Reconfirm Enrollee Poses Low Risk
- Ensure Enrollee’s Identity is Verifiable
TECHNICAL SYSTEM DESIGN

SWIFT Enrollment System

The SWIFT enrollment system is broken into five separate but sequential processes:

1. Application
2. Biometric Collection
3. Risk Assessment
4. Approval/Denial Notification
5. Enrollment/Activation

Unlike the airport and on-going systems, the enrollment system only requires a single set of actions per participant. Once a SWIFT applicant completes the five enrollment processes he does not need to pass through the enrollment system again.

Application

SWIFT enrollment centers, operated by the Transportation Security Administration (TSA), will be located within secure sections of participating airports. This makes logistical sense as these locations are closest to the target population of frequent travelers who have already passed the standard security screening. The enrollment centers will contain applications, instructions, and release forms for the background checks. SWIFT applications can also be available in PDF file format on a TSA or SWIFT-dedicated Internet site. The steps of the enrollment process should be clearly documented on the actual SWIFT application as well as on the Internet site.

Because the enrollment information required is likely to be extensive due to the requirements of the background check, the application will be designed so that an individual can complete it while waiting at an airport, during a flight, or while at home. The application form is likely to require detailed information about previous addresses, employment history, foreign travel history, financial information, etc. Therefore, it is unlikely that an individual will immediately complete an application at an enrollment center. Many individuals will take a SWIFT application form and complete it when they have time and access to the required information. Completed application forms will then be submitted, along with an applicant’s biometric information, when the individual returns to an enrollment center at a participating airport.
To generate interest in the SWIFT System, the enrollment centers will also be used to educate the target populations about the purpose and benefits of SWIFT. The expected time savings, convenience gains, and voluntary enrollment process will be articulated on kiosks or monitors. SWIFT information might also be distributed through TSA staff and the major commercial airlines.

Individuals will be charged an application fee for SWIFT enrollment at the time they submit their application. Payment is required with the application and will be made by credit card so as to expedite refunds to denied applicants. No cash or checks will be accepted since these would require extra setup and processing costs, and would make refunds (upon denial) problematic. Our research suggests that the target audience will be willing to pay an application fee of $50 to enroll.\footnote{See Chart 1 on page 17 for an estimate of SWIFT enrollees based on trip frequency and at a price of $50.} Evidence from outside studies also suggests that a higher enrollment fee might be acceptable provided that it correlates with visible time and hassle savings.\footnote{Vicusi, W. Kip, and Richard J. Zeckhauser. “Sacrificing Civil Liberties to Reduce Terrorism Risks,” Harvard Law School: John M. Olin Center for Law, Economics, and Business, Discussion Paper #401. http://www.law.harvard.edu/programs/olin_center/ (January 2003).} Once the SWIFT System is in production and has a stable number of enrollees, a small annual maintenance fee may be enacted for periodic updates of the security clearance and to make SWIFT more financially self-supporting. Because SWIFT is a voluntary system and frequent travelers will be encouraged to apply, the application fee should be fully refundable for those who are denied enrollment.

\textit{Biometric Collection}

At the enrollment center, a SWIFT applicant must submit biometric information in addition to his application. Enrollment must occur in person and on an individual basis. The biometrics required will consist of, at minimum, a primary biometric (iris scan) and a secondary biometric (finger scan). Other biometrics such as palm scans, facial scans, and voice recordings may be collected and retained to facilitate the background check or to ensure interoperability with other airport security systems. Enrollment centers might also contain automated kiosks to update an
enrollee’s biometrics without the need for additional TSA staff personnel. To help maximize value for TSA, an effort should be made to use the biometric infrastructure that will be built to accommodate its Transportation Workers Identification Card (TWIC) program. The SWIFT enrollment centers could also be used by transportation workers to collect and update their biometric information. For this reason, the selection of the SWIFT System’s biometrics should take those selected for the TWIC program into consideration.

Risk Assessment

An essential component of a successful and secure SWIFT System is the verification of the risk-levels of each potential enrollee. TSA will have sole discretion over which databases are searched and what the acceptable risk thresholds might be for SWIFT enrollees. Likely data sources used to compile the risk assessment might include the following:

- Past countries of residence
- Criminal history search
- Credit reports
- Motor vehicle reports
- Educational and professional licensing verification
- Employment history
- Residential history

Among the federal criminal history databases likely to be searched are: the National Crime Information Center (NCIC), Interstate Identification Index (III), and National Instant Criminal Background Check System (NICS).

Background checks will be conducted by TSA and federal law enforcement agencies. Each SWIFT applicant will be subjected to roughly the same level of scrutiny in his background check. A TWIC card will eventually be issued to each of the more than 15,000,000 airport, highway, rail, and port workers in the United States.\(^\text{30}\) In order to capitalize on economies of scale, the SWIFT System will eventually share the TWIC program’s background check infrastructure. This would provide for lowered costs as well as decreased turnaround time. A

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successful government effort to conduct large numbers of background checks quickly has been
demonstrated by the mandatory background check required of individuals purchasing
handguns.31

The need to conduct quick and accurate background check of federal criminal history databases
complicates expanding the SWIFT eligibility beyond US citizens. The logistical difficulties,
time, and expenses associated with performing identical background checks on foreign citizens
are likely to be prohibitive. The information maintained by each country differs, not all
countries have automated systems, and tighter privacy laws in some countries might prohibit
obtaining the necessary background check information. At a later date, TSA could explore
partnering with other foreign nations whose citizens travel frequently to the US, as they would
have the greatest incentive to develop programs similar to SWIFT in their own countries.

Approval/Denial Notification

Initially, the notification of SWIFT approval or denial is expected to take approximately six to
eight weeks. This time frame should lessen over time as the risk assessment processes becomes
more refined and as SWIFT migrates to the TWIC infrastructure. The official approval or denial
notification will be sent to applicants by mail. For those individuals who have been approved,
instructions regarding where and how to activate enrollment will be included. For those
individuals who are denied enrollment, information and instructions regarding the reason(s) for
denial may be articulated32, the appeals process will be explained, and a notification will be
included explaining that the enrollment fee will be refunded. Prior to the system launch, specific
steps for an appeals process should be developed to accommodate individuals who feel as if they
have been wrongly denied.

31 Since November 1998, the NICS has been used to verify the backgrounds (misdemeanor and felony records) of
individuals seeking to purchase handguns. It has processed over 10,000,000 inquiries and has searched over 35
million criminal records. Of those 35 million criminal records searched, over 500,000 wanted persons have been
identified, 200,000 persons subject to protective/restraining orders have been identified, and 1,000,000+ records on
other prohibited persons have been found. Since inception, NICS has denied transfer of firearms to an estimated
179,000 felons, fugitives, and other prohibited persons. Three national databases are checked: the National Crime
Information Center (NCIC), Interstate Identification Index (III), and National Instant Criminal Background Check
System (NICS) Index. Most system queries regarding handgun purchases are generally approved or denied within
30 seconds. The success of the NICS system might provide an indication of a similar threshold of security for the
**Enrollment/Activation**

Approved applicants are required to obtain cards in person to help prevent identification theft. There is also a cost savings associated with not having to pay for postage and packaging expense. Finally, because potential enrollees already travel frequently, it should be convenient for them to pick up the ID card at the airport. At an enrollment station, a person’s identity is matched to their previously submitted biometric information to authenticate identification prior to pick-up. The functionality of the card can also be verified at this time.

**Other System Stakeholders, Airlines, Corporations, Government**

Commercial airlines should be recognized as important stakeholders in the SWIFT System because of their ability to identify and refer frequent travelers. It should be assumed that airlines have a vested interest in encouraging frequent travelers to fly on routes with high time elasticities of demand to enroll in SWIFT. At a point in the future, the SWIFT System could consider integrating with the commercial airlines’ “rewards” programs so that they share a common token. The SWIFT System might also be able to share the branding rights of the card as a possible source of revenue. For the pilot program at Pittsburgh International Airport (PIT), US Airways has expressed an interest in supporting the effort.\(^{32}\) Those government and private organizations that have large numbers of employees who spend much of their time traveling by air (e.g. consulting firms, corporate executives, government agencies, etc.) might also be considered conduits for distributing information about the SWIFT System. While these organizations would not be allowed to directly enroll their employees (enrollment must be done voluntarily by an individual) they could encourage SWIFT enrollment by distributing educational information. These organizations could also allow their employees to use corporate credit cards to pay for the enrollment charge, although the applicant would still need to submit their own personal financial information to satisfy the requirements of the risk assessment.

SWIFT enrollment processes are depicted graphically as flow charts in Appendix B.

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\(^{32}\) Pamela Davis of US Airways her support for the project during the Advisory Board presentation on April 24, 2003 at Pittsburgh International Airport.
**SWIFT Airport Processing System**

The SWIFT airport processing systems are broken into two major processes, which are designed to meet the functional requirements of the system:

1. Use SWIFT token and apply biometric(s) to verify that the:
   a. Passenger is in possession of a SWIFT ID card
   b. Card was issued to that passenger
   c. Passenger is scheduled to fly
   d. Passenger remains in the low-risk category

2. Undergo expedited security screening

The airport process entails multiple iterations and is completed each time an enrollee flies.

*Verify Passenger is Low Risk*

When SWIFT passengers arrive at the front of the line, they wave their SWIFT card in front of the proximity card reader located just in front of the security checkpoint. They then apply their first “live” biometric and wait for the TSA representative manning the checkpoint to give them the signal to proceed through security. The TSA representative permits the passenger to proceed when he has received a “green light” indicating that the system has verified that the:

- Passenger is in possession of a SWIFT ID card
- Card was issued to that passenger
- Passenger is scheduled to fly
- Passenger remains in the low-risk category

Several processes, invisible to the passenger, occur to produce the “green light”. Upon application of his “live” biometric, the passenger’s biometric data is translated into a “live template” that is matched with the template stored on the card\(^{33}\). The “live template” and the identification number stored on the card are then transmitted to the local server. The number allows the system to locate the passenger’s profile on the local server. The live biometric template is again matched, this time to the biometric template associated with the SWIFT profile

\[33\] Matches occur within a pre-established degree of certainty.
held on the server. The system then checks other information associated with the profile on the server. For example, it confirms that the passenger is scheduled to fly. The system also verifies that the current risk assessment associated with the profile is “low”.

If the passenger’s first biometric information matches to the template with insufficient certainty, he is instructed to apply his second “live” biometric. In this case, the live templates from both the first and second biometrics are compared with the card and profile.

A traveler’s passage may, on occasion, be restricted. The TSA representative controlling the SWIFT access point is notified if the passenger’s live biometric templates fail to match those on the card or server. If both of their biometrics are compromised (for example, by injury to the eye and hand) or because they are not the person to whom the card was issued, the TSA agent manning the SWIFT station is notified of the degree of failure and may verify other information coded on the card or redirects the passenger to the non-SWIFT security screening.

*Expedited Security Screening*

The SWIFT System facilitates expedited processing through two sources of efficiency. It improves service rates through revised security constraints and improved process design.

**Revised Security Constraints**

Once a SWIFT passenger has been assigned a “green light”, the TSA operator permits access to the security checkpoint. SWIFT passengers, like all other airline passengers, are submitted to a rigorous security check. There are, however, some minor changes in the screening of SWIFT passengers that will lead to significant efficiencies over time. In the SWIFT System, passengers will undergo pre-September 11 airport security. This means that the passengers’ carry-on baggage only is scanned by the x-ray machine. Items that are scanned using the x-ray machine will pass through the machine without stopping. The walk-through metal detector (WTMD) is set to a slightly lower sensitivity than those at non-SWIFT access points. This will enable

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34A hash function is used to reduce the size of the live biometric template so that it may be sent quickly over the SWIFT network to the local server.
passengers who forget to remove small, low-risk metal objects from their pockets to pass through without setting off the alarm. If a passenger does set off the WTMD, they are permitted to remove the offending items from their person and make a “second pass” through the machine. As a result, time-consuming secondary searches, which involve the examination of the contents of baggage or the use of a hand-held metal detector, are thus less frequent in the SWIFT lane. It should be noted that, because SWIFT passengers have essentially undergone screening prior to their arrival at the airport (because they have submitted to an individual background check), security screening revisions do not amount to diminished security.

Improved Process Design

Improved airport process design also contributes to the increased efficiency of the SWIFT System. Our computer models have shown that redesigning checked baggage processing will enable TSA to screen 50 percent more bags per hour using the fast and secure CTX machines already located in most American airports. Our other simulations have indicated that reconfiguring security checkpoint lanes such that there are two x-ray machines per WTMD instead of one, as is common practice, can reduce wait times by up to 68 percent. Flowcharts and analyses illustrating the SWIFT airport security processes are contained in Appendix B.
**SWIFT Ongoing Systems**

The on-going system permits the SWIFT System’s goals to be met over time as exogenous factors change. The on-going system is intended to ensure the SWIFT System’s integrity over time. The on-going system functionalities may have several iterations, but will not occur with every flight. The SWIFT on-going system is comprised of three separate and non-sequential processes:

1. Reconfirm that the participant poses low risk/real-time risk assessment updates
2. Ensure that the participant’s identity is verifiable/credential re-issuance
3. Credential revocation

*Reconfirm that the Participant Poses Low Risk/Real-time Risk Assessment Updates*

The SWIFT System will initially be designed to handle batch updates of enrollee profiles. Eventually, risk information will be constantly fed into the system and will make the batch system unnecessary. The technological capability for the real-time system exists and should eventually be used.

*Ensure that the Participant’s Identity is Verifiable/Credential Re-issuance*

A process for re-issuing credentials over the life span of the cards will need to be developed. The cost for each card is estimated to be $4. However, it is expected that, as card technologies advance, costs will decrease. Self-service kiosks will be installed at airports and will prompt SWIFT enrollees to update their own biometric information at periodic intervals (e.g. six months, one year, two years, etc.).

Another idea for improving the credential re-issuance process is to incorporate an automatic update of an individual’s biometric information each time the SWIFT System is used. To accomplish this, the biometric equipment would need the capability to read an individual’s biometric information, match it to the card and/or database, and then re-write that biometric
information onto the card or database so that it can be verified the next time an individual passes through a SWIFT checkpoint.

_Credential Revocation_

Application forms will outline the conditions under which SWIFT enrollment will be withdrawn. Reasons for revocation will be determined by the TSA, but will likely include:

- Intelligence information (travel history, questionable associations, etc.)
- Arrest
- Bankruptcy
- Extradition

In an effort to make SWIFT more politically acceptable as well as financially feasible, a maintenance fee might be assessed to users once the system has been fully implemented and its value has been demonstrated. This user fee, as with making the system voluntary, will help insulate it from criticism that it benefits only a select few at the expense of the larger population.
ENABLING TECHNOLOGIES

The SWIFT System’s primary enabling technologies are the network, identification card, and biometrics. The following section describes these in detail.

Network

The network for the SWIFT System must possess the following characteristics to maximize the probability of correctly verifying the identity of SWIFT travelers including:

- High-speed operation
- Resiliency
- Protection of the confidentiality of SWIFT enrollees
- Scalability
- Ease of use
- Security

The system’s network will encompass the nation’s largest airports and will be composed of thousands of security checkpoints (access points), TSA will be being responsible for its configuration, maintenance, and daily operation. Thus, the SWIFT System is best organized by a hierarchical architecture comprised of a three-tiered system that consists of a central TSA office at the apex, followed by regional TSA centers, and local TSA offices at all participating airports at the base. The central TSA office’s primary network-related responsibilities include: conducting background investigations, data warehousing, data mining, and transmitting profiles to regional TSA centers. The regional TSA offices are primarily responsible for transmitting the profiles of SWIFT passengers to the local TSA branches along the SWIFT passenger’s itinerary and providing redundancy, in the event that other Regional Centers go offline. Local TSA primary responsibilities of the local TSA offices include SWIFT passenger verification and screening as well as program enrollment.

In order for TSA to cross-check all passengers against a watch-list and accurately verify the identity of a SWIFT passenger, it must construct an enterprise infrastructure that provides the
necessary storage capacity, bandwidth, and scalability to support its mission. Based on these requirements several preliminary recommendations can be made regarding the reservation and manifest cross-check, identity verification, data management, bandwidth, watch-list administration, and the next steps.

**Reservation and Manifest Cross-Check**

Unlike regular travelers, SWIFT passengers identify themselves by providing a SWIFT passenger ID number when making reservations over the phone, on the internet or in person. SWIFT reservations fall into two relevant categories: those that are made more than 24 hours from the scheduled departure and those made less than 24 hours prior to their departure. The manifests of the SWIFT passengers who have made their reservations more than 24 hours in advance are transmitted by the airlines in batches while reservations made within 24 hours by SWIFT travelers will be immediately checked against the TSA watch list and undergo the standard security assessment by the central TSA office. If a match is identified while TSA is cross-checking all travelers against its watch list, the central TSA office transmits an alert through the network via the TSA regional centers. If a SWIFT passenger does not match the watch list, then no action will be taken.

**Identity Verification of the SWIFT passenger**

A PC with two peripheral biometric devices and pre-installed biometric-verifying software will make a three-point match between the SWIFT passenger, the biometric profile on the card, and the profile stored on the local database. The requirement for a three-point match allows for added security and guards against counterfeit biometric cards. Those attempting to breach the system will be forced to create or augment an existing card, deceive the biometric device, and finally hack into the central TSA database to place their biometric profile into the system. The three-point match provides an extremely difficult hurdle to overcome and provides for the eventual migration to a card-less system.

**Data Storage and Transfer**
Data will be stored on and accessed exclusively through TSA controlled system components. SWIFT passenger enrollment data, the results of an individual’s initial background search, profile updates, travel history, and the TSA watch list will be located on the TSA mainframe. All airlines will transmit their manifests from their servers to the Central TSA. Central TSA will transmit SWIFT passenger profiles by way of the regional center to the departure, layover, and destination TSA sites.

Central TSA’s databases will be the primary repository for all SWIFT profiles. Based on initial estimates of profile size the central database will need to meet the following requirements:

- **Clustering Capability:**
  Enables TSA to link multiple servers for increased capacity and reliability. Processing tasks are divided among available servers, providing load balancing. A clustered configuration also provides automatic failover; if one server becomes inoperable, the other servers fill the gap, so there is no system downtime. As Central TSA grows, additional servers can easily be added to the cluster.

- **Storage Capacity:**
  - Estimated # of Profiles: 30 million
  - Estimated size of each profile: 1.5MB
  - Total Storage of at least 45 Terabytes

- **Costs:** Starting around $500,000 for server hardware and storage space

The configuration of a Regional Centers is shown in Figure 2. Its database will require enough storage space to contain all SWIFT profiles but only the portion of the profile necessary for identity verification. By only storing the portion of the profile for identity verification TSA will save on storage and bandwidth costs. Databases for local TSA will only need to store the profiles necessary for today and tomorrow’s SWIFT travelers. Among the requirements for the regional and local TSA centers are the following:

- **Database Software**
  - Database software costs: up to $1000 per license

- **Server Hardware**
  - Costs per server:
• Low end $7,500
• Med/high end $25,000

• Minimum Requirements
  – Storage Capacity
    • 7.5-10GB

**Bandwidth**

Bandwidth needs will vary based on the geographic distance between the Regional Centers and TSA Headquarters and on the expected amount of traffic. Airports that process a high volume of traffic will require greater bandwidth. TSA will need to negotiate service agreements with several ISP’s for connectivity between airports and Regional Centers and redundancy/reliability of those connections. Based on projected program participation we recommend TSA use leased lines with a capacity varying between T1 connections for smaller airports up to a T3 connection for the busiest airports. A major portion of the traffic on this private network will occur between Central TSA and its Regional Centers and will necessitate greater bandwidth. We recommend Optical Carrier 3 (OC3) lines to interconnect the Regional Centers and Central TSA.
Figure 2: Proposed Topology of SWIFT Regional Center

100 Mbps LAN

2Gbps Switch

Cluster Interconnect

Server

Server

Server

Server

2Gbps Switch

SWIFT Profiles

SWIFT Profiles

SWIFT Profiles

1-2 TB of Total Storage
In order for the system to verify a SWIFT enrollee prior to security screening, his identity must be verified. In the SWIFT System, this will occur through the comparison of the enrollee’s “live” biometric (such as a finger or iris scan) with biometrics stored on his SWIFT “smart card” and in the database.

A typical smart card has the same dimensions as a standard credit card yet it contains an integrated circuit which stores and processes information. A smart card’s processing capabilities enable it to perform the complex security functions essential to a program like SWIFT. It is capable of holding large amounts of data including algorithms and cryptographic keys used for digital signatures and other forms of encryption. It can also store large biometric templates as well as other identifying information. The SWIFT smart card, in particular, will:

- **Comply with the National Institute of Standards and Technology (NIST) “Government Smart Card-Interoperability Specification” (GSIT).**
  
  The NIST, in an effort to build a framework for interoperability among identification cards and card readers, has set specific requirements and guidelines for all government issued cards. This compatibility allows for ease in future expansion and reduces costs by allowing sharing among different agencies.

- **Contain a microcontroller with at least 32 kilobytes of storage capacity.**
  
  Thirty-two kilobytes is sufficient storage to hold the biometric templates for our two chosen technologies while leaving plenty of room for other identifiers and algorithms.

- **Have contact-less capability**
  
  A contact-less (or proximity-enabled) card reader helps to extend the life of the card by preventing wear and tear usually experienced from sliding friction.

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• **Incorporate security features such as encryption, hash functions, tamper-resistance functions, holograms, and digital photos.**
  Built in security features helps to prevent identity theft and ensures that the individual holding the card is in fact the owner of it.

• **Have read and write capability**

• **Have a data transfer rate greater than 50kb per second**
  It is important to that the card has a data transfer rate of at least 50kb per second in order to prevent delays and holdups in the SWIFT passenger lines.
**Biometrics**

To a large degree, the effectiveness of the SWIFT System is tied to its ability to verify that an individual is indeed who he or she claims to be. In today’s society there is no better means of accomplishing this task than through the use of biometric systems. This section addresses some of the choices related to biometric system selection and implementation and provides a basic overview of the three-front running technologies for SWIFT implementation: facial scans, finger scans, and iris scans.

**Overview**

Before an effective comparison of biometric systems can be made, it is important to develop an understanding of the factors that determine their effectiveness. Biometric systems are measured in terms of three distinct capacities: False Match, False Non-Match, and Failure to Enroll. The False Match Rate (FMR) is the likelihood that a system will verify a card carrier as the card owner if he is not. The False Non-Match Rate (FNMR) represents the chance that a user will be falsely rejected by the system, i.e. someone will not verify as himself. The value at which FMR and FNMR are equal is referred to as the Equal Error Rate (EER). The third measure, Failure to Enroll (FTE), is the rate that individuals in the enrolling population are unable to provide verifiable biometric data to the system. As these measures will show, no biometric system is perfect.

The relative importance of these metrics depends on the goals of the system. Within SWIFT, the focus is security with a primary objective of keeping unknown passengers from undergoing expedited security before entering the “sterile” areas of the airport (areas accessible only to ticketed passengers). This goal establishes the FMR as the most critical of the three measures and suggests it should be the focal point of minimization efforts. There is interplay among these three measurements that must be considered. For example, a decrease in the FMR will balance against an increase in the FNMR. Or a decrease in the FTE may cause an increase in both FMR
and FNMR. As with all biometric implementations, an important consideration for SWIFT is to achieve the proper balance.

The SWIFT System has a number of advantages for achieving a low FMR:

1. Participation in SWIFT is voluntary, which eliminates the need to ensure that all users are capable of interacting with the system. This allows for FTE concessions to be made that might otherwise be impossible.

2. The standard security lines provide an alternative pathway through which SWIFT passengers who have been unable to enroll or who are falsely rejected can pass. For many biometric systems, establishing this alternative pathway for these individuals is both costly and difficult.

3. The SWIFT System is to be a “multiple biometric implementation”. This enables the system to combine the best of two or more biometric measurements to achieve more robust operation.

One mitigating factor to consider is the necessity of satisfying the SWIFT traveler as a customer through convenience and time savings. This effort forces the maintenance of a reasonable cap on the resulting FNMR. The International Biometrics Group, in their examination of biometrics in travel applications, deemed that an EER of 0.1-0.2% and a FTE of 1-2% should be acceptable.

Process

At enrollment, an individual provides a given number of training images that are compared, combined, and processed to produce a template. A template is a small file derived from the distinctive features of a user’s biometric data. For comparison, consider that most templates are smaller than 1Kb whereas it may take upwards of 100Kb to capture a complete image. This

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36 Multiple biometric implementations are discussed in detail later in this section.
37 www.biometricgroup.com
template becomes the match template, and, after its validity has been accessed it is stored to a card and/or database. Biometric data cannot be restructured from a template – a key privacy issue. To verify or identify an individual, an image is provided through biometric capture that will be resolved to a live template and compared with the match template. This comparison produces a score that, if beyond a specified threshold, will result in a match.  

Technologies

Three leading technologies have been identified as candidates for SWIFT implementation: facial, finger, and iris scans. Each of these technologies brings with it an array of advantages and disadvantages that, depending on system goals, may make it better suited to implementation.

Finger Scan
Finger scan technologies represent over half the present day biometrics market and are available from a multitude of providers. Within this segment, market leaders include Identix, Bioscrypt, Sagem, and Siemens. The majority of finger scanning technologies are based around the referencing of minutiae that identify the unique nature of fingerprints. These minutiae are recognized as departures from the swooping arcs and rings of the finger, including ridge endings, bifurcations, deltas, and islands among others. Such technologies use between 15 and 50 of these events and their interplay to create a template that can be used in matching exercises. Finger scan templates range in size from as small as 9 bytes to as large as 1000. An alternative finger scan technology focuses around pattern matching algorithms. While this technology has proven more capable of handling print wear, it is far more sensitive to alterations in user placement. In addition to these two processing strategies, there are three competing methods for image capture: optical, silicon, and ultrasound. At this time, optical seems the most dependable choice for SWIFT implementation because silicon technology has been shown to have limited durability and ultrasound technology is still in its infancy.

Finger scan technology has a number of unique advantages within the biometrics market. The technology is:

- Generally well accepted within the community
- More mature than its competitors
- Able to leverage large databases of fingerprint data already collected (making it both a potent verifier and identifier)
- Relatively easy to use
- Compatible with the enrollment of multiple fingers (useful because it can increase accuracy while overcoming the varying stability of fingerprints due to wear)

In contrast, finger scans are saddled with one noteworthy disadvantage. Finger scans have a rather high FTE due to the frequent inability of the elderly, artisans, and others working with their hands to enroll. In fact, studies have shown a significant drop in accuracy even over time periods as short as six weeks.

Facial scan technologies, like finger scan technologies, are produced by a number of companies including Identix, Viisage, and AcSys, among others. Facial scans operate as software packages running on top of existing or dedicated video capture equipment. The templates employed by facial scans can be up to 3,000 bytes in size and allow for a great deal of flexibility. They can be created from a single photograph (such as a criminal watch list photo), from in excess of 100 still photos, or from video. Not surprisingly, the more photographic data used to create the template, the better the results will be in operation.\(^\text{40}\) The two most popular processing methodologies for facial scans are Eigenface and Feature Analysis. Eigenface creates a template from a database of two-dimensional grayscale images used to map facial characteristics. The alternative, Feature Analysis, is employed by the majority of facial scan systems and works by pinpointing and mapping dozens of features from different regions of the face.\(^\text{41}\) Both technologies favor facial

\(^{40}\) Nanavati. Page 65.
\(^{41}\) Nanavati. Page 70.
features that are least likely to change over time, including the ridge over the eye, cheekbones, sides of the mouth, and shape of the nose.

Advantages of facial scan technologies include:

- The ability to leverage existing image capture equipment and infrastructure
- A wide range of possible combinations from which to create the match template
- A contactless system that does not require the cooperation of the user

Unlike finger and iris scanning technologies, facial scanning technologies are particularly well-suited to surveillance implementations. This is due primarily to their ability to function without user cooperation or involvement. Additionally, as a contactless system, a facial scan would be preferred by some users to the contact of a finger scan. From a security perspective, the ability to leverage millions of pictures held in derogatory databases and existing acquisition devices is an important advantage. Facial scans do not excel in terms of FNMR, as they are highly susceptible to user presentation errors, environmental effects, and physical changes. While present systems’ responsiveness is improving, not shaving or inconsistent lighting could well likely be enough to force a FNMR. With these elements in mind, present facial scanning systems seem better suited to identification as opposed to verification missions. The National Institute of Standards and Technology’s forthcoming Facial Recognition Vendor Test should soon shed some light on this technology’s suitability for projects such as SWIFT.

Iris Scan
Presently, Iridian is the only provider of iris scan technology. The Iridian system uses infrared illumination to take an image of the iris. While earlier systems required extensive user interaction to properly position the eye 18” from a camera, new kiosk-based systems allow the user to remain two to three feet away. A twin camera system is then used to locate the eye and capture an image of the iris. This image is then compared to a match template of 512 bytes, which is developed using one to four training images. The information derived from the 11mm
diameter of the iris focuses around 266 unique spots. This is an incredibly large number of unique identifiers when compared with the number used for a fingerprint scan.\footnote{Medin Marketing Ltd, \url{www.biowebservcom/BIO_irisscan.htm}}

Iris scan technology has the following strengths, which set it apart from other biometrics on the market:

- More stable biometric characteristics over a person’s lifetime (as opposed to other biometric technologies)
- Highest potential accuracy for a biometric identifier
- Both the left and right irises can be enrolled allowing for an increase in presentable data and resulting accuracy
- Highly unlikely to experience environmental concerns because image capture employs infrared light

The iris makes a worthy biometric identifier because of its wealth of unique data, highest potential accuracy, and more importantly, its unparalleled stability. A person’s iris remains relatively stable after childhood except in extreme cases of eye trauma, which should significantly reduce any need for re-enrollment. This sets it far apart from other biometric identifiers, which are subject to natural alteration. Like the finger scan, the iris scan also offers opportunities for enrolling multiple examples, as the left and right eyes are both unique. Iris scanning is also relatively immune to environmental factors, counting on infrared light for image capture. Historically speaking, the major disadvantage of iris-based systems has been perceived discomfort of use and high cost. If Iridian has been able to address these concerns with their new kiosk-style system, the only remaining disadvantages include user uneasiness with eye-based technologies and potential TSA uneasiness with dealing with a single-provider technology.

**Implementation**

When considering implementation strategies, there are three primary biometric architectures:

1. Single, stand-alone biometric technology
2. Two “or” biometric technologies
3. Two or more “fused” biometric technologies

A single, stand-alone biometric architecture isn’t a realistic means to achieve Swift’s objectives, which are clearly best supported by the use of two or more biometrics. Following TWIC, the multiple biometric system offers several advantages. The simplest option is the use of an “or” system that employs two stand-alone biometrics. This arrangement allows for a second system to serve as a back-up to be used following failure of the first. While this architecture does decrease the FNMR and FTE by presenting users with more options, it offers all users a system alternative for which they may be better suited. It does not take full advantage of the technology, and thus, does not realize the potential of the capital invested because it fails to integrate the system. Another concern relates to the less frequently used back-up technology. Travelers will likely not become adept in its use, and as a result, this technology’s performance may suffer.

With a “fused” system, two biometric technologies operate in concert. This arrangement involves linking the decision-making criteria of the two biometrics so that they operate as a single system. Because acceptance levels between live and match templates can be consistently adjusted, they can be reconstituted to incorporate the two separate system measurements to provide a single answer. This flexibility allows the passage of either biometric with a certain degree of certainty (99.5%) or permits passage after passing a slightly more conservative threshold (97%) for each.43 An ideal fused system implementation captures both biometrics simultaneously. This scenario is technically feasible and easy to imagine. For instance, iris scans and facial scans could be taken at the same time.

At present, there are two likely providers for a “fused” system on the market: Identix (which trades in both finger scan and facial scanning systems) and Iridian and Sagem’s recent alliance to develop an integrated finger/iris scanning system. If neither of these systems conform to SWIFT requirements, it is conceivable that a union could be made between any two biometrics, though at far higher cost.

Proper implementation of a biometric system necessitates consideration of process as well as technology. System performance is heavily influenced by effective front-end preparation. For example, the better the initial match templates created for users, the more effective they will be in verifying identities in the future. Additionally, educating users on how to interact with the biometric capture systems will greatly enhance system performance. User education alleviates presentation errors that account for a great deal of FNM occurrences--environmental effects and physical changes are at fault for the remainder.

**Recommendations**

Because TWIC will use finger scanning technology, it is cost-effective and practical for SWIFT to use finger scanning, as well. In achieving its goals and meeting the mandate advanced for the program, SWIFT will benefit most from the adoption of technologies that are both stable and accurate. This is a clear mandate for the use of an iris scan. This decision requires an agreement to be reached with Iridian that neutralizes ill effects the single provider model could produce, but should be well worth it for the elimination of re-enrollment certainties alone.

The finger and iris scans should operate in fused fashion with individuals first taking the iris scan. It is hoped that in the vast majority of cases iris scans will be effective enough to largely eliminate the need for finger scans, but users should be educated about both systems regardless. A facial scanning software package has the added benefit of possibly being integrated into airport surveillance to search for individuals on criminal and international watch lists. However with the technologies that are available prior to the release of Facial Recognition Vendor Test 2002, facial scanning is not yet able to provide reliable and consistent verification of individuals in the manner SWIFT would require.
SYSTEM MODELING

Security Checkpoint

After establishing the necessary precursors to implementing a SWIFT System, it is important to determine the benefits of such a system. In order to quantify the costs and benefits of proposed SWIFT configurations at airports, current airport screening operations were modeled to obtain base values. Various processing configurations were then modeled to illustrate the changes in time, throughput, and delay.

Policy Changes
Primary airport checkpoint security consists largely of screening carry-on bags using an x-ray device, and screening individuals using a walk through metal detector (WTMD). After September 11, 2001, however, the federal government began to modify the security procedures at the nation’s airports. Prior to September 11th, anyone was allowed into the secure side of the terminal after passing through the security checkpoint. Additionally, individuals were allowed multiple passes through the WTMD in cases where passengers’ first passes resulted in an alarm. Furthermore, small, pocket items such as keys and mobile phones could be passed around the x-ray machine instead of being screened.

Since September 11th, policy changes have affected the throughput of the security checkpoint. Although fewer passengers now undergo the screening process, delays associated with security have increased significantly. The primary changes in security screening policy are outlined below:

- Each piece of carry-on baggage must be stopped inside the x-ray machine to be examined before it can be cleared to pass into the secure (airside) section of the airport
- Pocket items, such as mobile phones, wallets, and keys must be x-rayed rather than simply passed around the WTMD and handed back to the passenger
- Only airport employees and passengers may pass through the checkpoint
- If an individual causes an alarm from the WTMD (perhaps due to keys in a pocket), he or she is required to go through a secondary screening procedure,
involving wandling and shoe removal; prior to the policy change, an individual in a similar situation could simply remove the keys from their pocket and pass through the WTMD a second time

- WTMDs are calibrated to a higher sensitivity and will alarm in response to smaller quantities of metal

The combined effect of these policies is fourfold:

- Individuals spend less total time passing through the WTMD because ‘second passes’ are no longer permitted
- Each individual has more objects which must be screened by the x-ray machine as pocket items must now be x-rayed
- As non-traveling persons may no longer enter the sterile area, a lower number of individuals pass through the checkpoint without bags which raises the average number of bags per person passing through the checkpoint
- Since the x-ray conveyor belt must be stopped for each piece of baggage, more time is required to screen each bag.

Our models for the SWIFT System are based primarily on observations of checkpoint operations at Pittsburgh International Airport (PIT). A brief description of current checkpoint operations follows.

**Current Checkpoint Operations**

Before a passenger enters the checkpoint screening area, his or her boarding pass or employee credentials are checked by security contractors. After the credentials are checked, the passenger continues to the security checkpoint. At PIT, the security checkpoint consists of seven parallel lanes. If an individual has been identified as a “selectee” by the Computer-Assisted

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44 The problem is aggravated by the fact that the x-ray machines currently in place were not designed for start/stop operation.
45 Credentials of employees, coach passengers and priority passengers credentials are checked at three separate points. Priority passengers are those who are either flying first class, or are members of one of the various “elite” frequent flyer groups.
Passenger Screening (CAPS) I system, he will be escorted to the selectee-dedicated lane at the far right. The far left lane (lane one) is primarily reserved for ‘priority’ passengers. Because screening procedures are identical across lanes, anyone can use the priority lane when its queue is empty, but when full it is for the exclusive use of first class passengers and various frequent flyer club members. Lanes three through five are unrestricted, general use lanes. They are used primarily by coach passengers, although they can also handle employees or priority class passengers. Lane six is generally dedicated to handling employees, including airport employees, security personnel, or airline pilots or flight attendants. Lane seven, as mentioned previously, is dedicated to CAPS I selectees. While all such selectees must use this lane, it can also be used by non-selectees. However, all non-employees using this lane must undergo a secondary screening. Each pair of lanes other than the selectee lane (1 & 2, 3 & 4, and 5 & 6) share a 'bullpen” staffed by three or four TSA employees who perform secondary screenings. When the queue for secondary screening reaches a length of four, the primary screening lanes feeding it are temporally halted until the bullpen queue length drops below four.

The net effect of the security checkpoint changes outlined above is a significantly lower throughput per lane. A SWIFT System could help to increase throughout by focusing on processing enhancements that impact the relatively small percentage of travelers who comprise a significant percentage of flyers at peak times (as was described in the demand section of this paper). If the small percentage of frequent travelers participated in a registered traveler system that reduced checkpoint screening time by even a small amount, the overall checkpoint throughput would increase significantly.

In order to increase checkpoint processing throughput, the SWIFT System would make the following changes to the current checkpoint processing:

- The magnetometer x-ray belt becomes continuous rather than being required to stop for the operator to inspect each item
- Passengers are allowed to remove metal objects from their person and attempt a second pass through the magnetometer if they caused an alarm on their first attempt

46 Dedicated lanes are not always exclusively reserved for priority travelers or employees. Coach passengers are occasionally allowed to use the priority or employee lanes, even at peak periods
Current Situation Model

In order to ascertain the potential benefits of various configurations of a SWIFT System, “time and motion” studies associated with the screening checkpoints were conducted. Four types of screenees with different characteristics were observed and measurements were taken. For example, data on the distribution of the number of bags that each type of screenee typically carried was collected. We also measured the time delay associated with screening each bag, and the time required for individuals to pass through a WTMD.

The four types of screenees we defined were:

- Flight crew members who usually carry luggage
- Ground-based airport employees usually do not carry luggage, but often carry other personal items
- Coach Passengers
- Priority Passengers

We found that the mean number of bags that coach and priority passengers carried was approximately 3.1 items and that the average time required to x-ray a typical bag was about six seconds.

During peak arrival periods, the seven security checkpoint lanes are unable to handle the demand for screening required to maintain steady-state operation. Thus, the queue builds up quickly during periods where arrival rate exceeds service rate, and queue length falls off quickly at the end of this period. Because queue length is uncertain, the variance becomes the determining factor in airport arrivals, and the 95th percentile of waiting time dictates how early an individual

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47 For our purposes, a ‘bag’ is defined as one or more objects which require a single belt stop within the x-ray machine. Thus a business traveler may carry a briefcase with a laptop, miscellaneous pocket items, and possibly shoes with steel shanks. If the traveler places his briefcase on the belt alone, and then places his miscellaneous items and shoes in one bin, and his laptop in a second bin, he would have three items.

48 We modeled this six second period as a gamma distribution with parameters =2, and =3. Consequently, the average primary screen of a non-employee required 18 seconds.

49 In steady-state operation, passengers enter the system at the same rate as they exit.
arrives at the airport. Thus, both the variance and the mean play a critical role in determining an individual’s time cost of delay.

We built a model of the seven lane configuration currently in use at PIT with Arena simulation software. We benchmarked its performance against observed waiting times at PIT to validate the model, and then used the results it produced as a baseline to compare with the SWIFT System. It is important to realize that the model does not just take into account primary security screening, but it also makes use of TSA operating procedures affecting which screenees use which lanes and which screenees receive a secondary search.

The Arena model of current checkpoint operations at PIT was run for two hours at peak arrival rates. We then used mathematical calculations to estimate maximum time in system based on accumulated queue length at the end of the two hour simulation.

Results

Using this model, we found that the average time in the system was 19.5 minutes for coach passengers, 6 minutes for employees, and 2.5 minutes for priority passengers. The longest wait for coach was estimated at 34 minutes. Because both the employee and priority queues were operating in steady state, maximum times and average times were quite similar (about 11 minutes and 9 minutes, respectively).

Given the time cost of delay model developed in the demand section of this report, every coach passenger passing through airport security during a peak period will arrive 30 minutes earlier in order to get through security. This represents a significant economic cost.

SWIFT Security

By implementing a continuously moving x-ray belt, we believe we can reduce the time required to x-ray an individual bag from 6 seconds to 4.5 seconds. This would, consequently, reduce the

50 People generally want to ensure that they will make their flight with 95% probability. Thus we estimate that people generally arrive $\mu + 2 \sigma$ minutes in advance.
51 Peak arrival rates are a total of 3,800 people passing through the checkpoint within two hours through seven lanes.
average primary screening from 18 seconds to 13.5 seconds (a decrease of 25%). This means that throughput of an individual lane would increase by 25%, thus decreasing the load placed on other lanes. This is, of course, provided that there are enough people enrolled in the SWIFT System to ensure that the SWIFT lane is continuously utilized.

That the SWIFT System permits members a ‘second pass’ initially seems to decrease lane throughput, as the WTMD is occupied during an individual’s second pass. However, the utilization of a WTMD in a 1:1 lane design (see Appendix C) is so low that even if every individual passes through the WTMD twice, no significant delays are anticipated. Additionally, allowing a second pass eliminates the time consuming procedure of ‘wanding’ a passenger when, for instance, he forgets to remove keys from his pocket.\footnote{The benefit of this system is not limited only to SWIFT enrollees, however, as average time-in system for non-SWIFT passengers decreased due to the decreased load on the system. Additionally, TSA employees can be redistributed to focus on non-SWIFT lanes to conduct more secondary searches on travelers of whom TSA has limited knowledge.}

\textbf{SWIFT 1 X-Ray to 1 Magnetometer Model}

To determine the SWIFT System’s effect on checkpoint efficiency, an Arena SWIFT model was built. The model assumed all employees were treated as enrolled as SWIFT enrollees and that 40\% of travelers on a given day would be enrolled.\footnote{We modified three lanes to conform to proposed SWIFT procedures and dedicated these lanes for SWIFT and employee use only. Besides the x-ray and magnetometer alterations, two biometric stations were added to be used to verify SWIFT membership. The verification process took five seconds on average.\footnote{It was estimated that 3\% of the SWIFT population would either fail biometrics or be selected for an automatic secondary screening. The non-SWIFT procedures remained the same and non-SWIFT travelers used four lanes, one of which is dedicated to the screening of selectees.} We modified three lanes to conform to proposed SWIFT procedures and dedicated these lanes for SWIFT and employee use only. Besides the x-ray and magnetometer alterations, two biometric stations were added to be used to verify SWIFT membership. The verification process took five seconds on average.\footnote{This was determined using a bimodal distribution to represent the time it takes to present a user’s biometric once, and then to present the biometric for a second time, if the first presentation failed.}} We modified three lanes to conform to proposed SWIFT procedures and dedicated these lanes for SWIFT and employee use only. Besides the x-ray and magnetometer alterations, two biometric stations were added to be used to verify SWIFT membership. The verification process took five seconds on average. It was estimated that 3\% of the SWIFT population would either fail biometrics or be selected for an automatic secondary screening. The non-SWIFT procedures remained the same and non-SWIFT travelers used four lanes, one of which is dedicated to the screening of selectees.

\footnote{We incorporated this innovation into our Arena model by increasing the average time required to pass through a magnetometer, and subsequently, decreasing the percentage of SWIFT enrollees that went on to secondary screening.}

\footnote{The 40\% enrollment was determined by the survey results.}

\footnote{This was determined using a bimodal distribution to represent the time it takes to present a user’s biometric once, and then to present the biometric for a second time, if the first presentation failed.}
When SWIFT procedures were modeled, the average time in system for SWIFT passengers and employees dropped to less than 1.5 minutes and had a maximum time in system of about five minutes. The most significant time savings was for coach passengers who did not join the SWIFT System. These passengers’ average time in system dropped to 12.1 minutes with a maximum time of 20 minutes. However, this time savings for non-SWIFT passengers under counts the efficacy of the SWIFT System because non-SWIFT passengers have a greater chance of having a secondary search than before.

<table>
<thead>
<tr>
<th></th>
<th>Current System</th>
<th>40% SWIFT &amp; TWIC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Wait:</strong> Priority to SWIFT</td>
<td>2.5 min</td>
<td>1.35 min</td>
</tr>
<tr>
<td><strong>Average Wait:</strong> Priority to Non-SWIFT</td>
<td>2.5 min</td>
<td>12.1 min</td>
</tr>
<tr>
<td><strong>Average Wait:</strong> Coach to SWIFT</td>
<td>19.5 min</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Average Wait:</strong> Coach to Non-SWIFT</td>
<td>19.5 min</td>
<td>12.1 min</td>
</tr>
<tr>
<td><strong>Average Wait:</strong> Employees</td>
<td>5.9 min</td>
<td>1.28 min</td>
</tr>
<tr>
<td><strong>Percent Non-SWIFT Subject to a Secondary Search</strong></td>
<td>27.5%</td>
<td>39%</td>
</tr>
</tbody>
</table>

**Lane Reconfiguration**

At the security checkpoint, it was observed that the magnetometers were not being used as efficiently as possible. Because it takes, on average, eighteen seconds to x-ray an individual’s bags and only a few seconds for an individual to pass through a magnetometer, a magnetometer
that is staffed by a TSA employee is used at below fifty percent capacity. Consequently, having one magnetometer for each x-ray is an inefficient configuration.

At PIT, if one magnetometer for every two x-ray machines was removed, another x-ray machine would be able to fit within the space limitations of the airport's current security checkpoint. Our models indicate that reconfiguring the checkpoint lanes such that every magnetometer was accompanied by two x-ray machines dramatically reduced the time-delay associated with the security process by 68%. Additionally, reducing the total number of magnetometers results in a decrease in required staff, as each magnetometer requires one TSA employee.

**Baggage**

Following the mandated screening of all checked baggage on January 1, 2003, travelers using PIT experienced long delays during peak periods. Because the TSA security mandates are relatively new, PIT, like many other airports, has yet to migrate to an ‘in-line’ system for screening checked-baggage. As a result, passengers with bags to check are required to accompany their bags to a baggage screening area where they must wait until their bag has been screened before proceeding to the security checkpoint. This additional delay and uncertainty further aggravates the already difficult delay situation facing flyers today.

The current checked-baggage screening procedure is also costly in that the TSA must maintain staff levels sufficient to handle peak loads. During a typical peak period at PIT, the US Airways terminal must process 600 bags an hour. Currently, TSA has only one CTX machine in the US Airways area and must rely heavily on personnel to conduct manual searches using ETD technology. Process measurement and observation indicated that the CTX’s were not being used to their maximum capacity. There was a 35 second delay when a CTX machine alarmed a bag; during that time, a TSA employee would walk to the single monitor and observe the image of the alarmed bag. The employee would memorize the location and nature of the suspicious item before returning to the end of the conveyor belt to pick up the bag to be searched. By reducing that delay, more bags could be searched by the more secure method of a CTX scan.

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55 As measured at PIT.
By integrating a screen capture device with the CTX and with monitors at the secondary search stations, the delay associated with an alarmed bag can be greatly reduced. If the delay is reduced to only five seconds, a CTX machine can scan 50% more bags. At PIT, this modification on the US Airways CTX machine would reduce the need for four ETD stations and would save TSA Pittsburgh $458,000 a year.\textsuperscript{56}

\textsuperscript{56}Appendix D.1: Analysis of Checked Baggage Operations at PIT, contains further details and the spreadsheet analysis of checked baggage operations.
SYSTEM COST

Throughout the development and analysis of the SWIFT System, we have identified many system costs and benefits. Determining the overall desirability and feasibility of the system warreants synthesizing these findings into a comprehensive picture of the overall system value.

SWIFT costs should not be seen as stand-alone. Because SWIFT shares many of the same infrastructure needs as the Transportation Workers Identification Card (TWIC) program, it is advisable for SWIFT to piggyback on TWIC. SWIFT System costs, then, will be estimated here as the marginal cost of operating the system given the prior existence of the TWIC infrastructure. All cost estimates are approximate and apply to a SWIFT implementation at Pittsburgh International Airport.

As mentioned previously in this report, the SWIFT System’s benefit comes from three primary sources: a reduction in perceived ‘hassle’ of security screening, heightened security due to the reallocation of security resources and a reduction in passenger time spent undergoing security screening. Due to the difficulty associated with measuring the first two benefits, this section will focus on summarizing the more quantifiable system benefits.
The following table summarizes our cost and benefit estimates for the various system components:

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Expenditures</strong></td>
<td></td>
</tr>
<tr>
<td>Enrollment</td>
<td>Enrollment</td>
</tr>
<tr>
<td>8,900</td>
<td>1,976,000</td>
</tr>
<tr>
<td>Baggage Handling</td>
<td>Baggage Handling</td>
</tr>
<tr>
<td>4,000</td>
<td>917,280</td>
</tr>
<tr>
<td>Security Screening</td>
<td>Security Screening</td>
</tr>
<tr>
<td>3,500</td>
<td>2,430,833</td>
</tr>
<tr>
<td><strong>Operating Expenditures</strong></td>
<td></td>
</tr>
<tr>
<td>Enrollment&lt;sup&gt;57&lt;/sup&gt;</td>
<td>3,236,740</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td><strong>Total Benefits</strong></td>
</tr>
<tr>
<td>$3,253,140</td>
<td>$5,324,113</td>
</tr>
<tr>
<td><strong>TOTAL BENEFITS-TOTAL COST</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$2,070,973</td>
</tr>
</tbody>
</table>

In only one year, SWIFT provides over two million dollars more in savings than it consumes in resources. Although, capital expenses will have to be replicated for each participating airport, they are clearly not the primary cost drivers. It is also reasonable to expect that the system will increase in value over time. Benefits to enrollees will increase as they experience expedited screening at increasing numbers of airports. Costs will decrease as capital costs are spread over increasing numbers of system participants.

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<sup>57</sup> Operating expenditures are estimated at one year marginal operation.

<sup>58</sup> The primary cost drivers here are the $75 background check and $4 card cost per participant.
PILOT TEST

Before considering implementation of the SWIFT System nationwide, pilot testing must be conducted to assess the system’s operational safety, effectiveness, and efficiency and to identify and solve potential problems that may arise. While the SWIFT System will eventually connect airports nationwide to a national database, the initial testing of system components will be conducted at a single airport. Subsequent tests will include more airports, ultimately leading to a nationwide adoption of the system. During each test phase it is important to determine any potential problems and measure important indicators of safety, efficiency, and user acceptance. To proceed to the next phase, a set of predetermined goals must be achieved and any unexpected problems must be resolved. We expect that it will take between six months and a year for a limited system to be developed and an additional year before the national SWIFT System can be fully implemented. A summary of all the pilot phases is provided below. A detailed table that outlines the components of the test design is available in Appendix F.\(^{59}\)

Phase I-A

The first phase of the SWIFT pilot will test the reliability of the SWIFT identification process. In this phase, biometric technologies will be configured using the ‘or’ architecture. Postponing the integration of the biometrics into a fused system will facilitate the evaluation of each biometric technology independently. In addition to biometric technologies, card and card reader equipment will be evaluated, as will be the system computers and local database. At this stage, user acceptance of the system will also be gauged through communication with participants (through surveys and focus groups) and through observation.

Because airport and airline employees have already received a background check, they are used as the initial test population. This is advantageous in that no investment needs to be made in background checks prior to early testing.

\(^{59}\) For more information, please see Appendix F: Detailed Test Pilot Design.
After the biometrics have proven that they correctly identify and minimize false rejections of users to a satisfactory level at PIT, and the other components of the system are functioning properly, phase I-A will be replicated at several other airports chosen to participate in the pilot. After these other airports have passed all the tests for the first phase, PIT can begin phase I part B.

Phase I-B

In phase I-B of the SWIFT pilot, network connectivity will be established between the checkpoint PC, a local server and a national server at TSA headquarters. This will permit initial testing of the network, servers and databases. Also at this stage, the checkpoint x-ray machines will be reset such that their belts move continuously, as they did prior to September 11. Policy will also be altered such that employees will be permitted to make a second pass through the magnetometer should they alarm the first time. Again, employees provide an ideal test group because their ‘trusted’ status renders potential breaches of security caused by system bugs less worrisome.

Phase I-B is essential to the success of the SWIFT pilot because it will help prove that the changes do not compromise security. Permitting second passes through the walk-through metal detector (WTMD) in the SWIFT lane will reduce the number of secondary searches conducted on those passengers, thus permitting secondary screeners to conduct more searches on non-SWIFT passengers. This shift should increase security. Furthermore, while simulation models have determined that the SWIFT process drastically increases throughput of each security lane, measurements will be taken during this phase to determine the actual efficiency gains. Once the procedures are deemed secure and efficient at PIT, other airports in the pilot should begin phase I-B. PIT will then begin to enroll the most frequent travelers for participation in the next phase.
Phase II-A

The enrollment process must securely, accurately, and cost-effectively register qualified travelers into the SWIFT System. It is important that individuals be unable to either forge or issue a card illegally (input an individual with a clean history with someone else’s biometrics). It is important to measure the cost and security of the enrollment process. To prevent untenable system growth at the outset, only a limited number of the most frequent travelers will be permitted to voluntarily enroll at this stage.

Once enrolled, the SWIFT passengers would go through the same security process as in phase I-B (i.e. continuous belt x-ray and second pass through the magnetometer). As with the last phase, the security and efficiency of the process must be measured. It is also crucial at this stage to again test user acceptance of the system, as the users and their expectations could change.

Because other pilot airports are now networked to the central TSA database, this phase is appropriate to begin evaluating the effectiveness of the national network as it expands.

After phase II-A at PIT has been found to be acceptable, other airports will begin implementing phase II.

Phase II-B

By this stage, the system should have demonstrated that it operates reliably. Once enough airports are involved PIT will now permit all frequent travelers to apply for SWIFT enrollment. An enrollment fee will now be charged. This will enable the fee collection system to be evaluated. The system’s overall ability to handle increased demand will also be observed. During phase II-B, the same measurement process will occur as happened with phase II-A, and will then expand to the other pilot airports once all processes pass a specific measure.
Phase III

The transition from phase II-B to phase III should be uncomplicated because the only significant change regards the expansion of the eligible population. In phase III, PIT will allow any passengers who are US citizens to apply for a card. This is the same population that will ultimately be permitted to enroll in SWIFT at any participating airports. Phase III is the final phase of the pilot. As with previous stages, other pilot airports will initiate this phase upon PIT’s completion. With the successful completion of the pilot at PIT and the other pilot airports, SWIFT can be gradually introduced to other airports nationwide.
Recommendations

Based on the findings contained within this report, a list of recommendations on how to best implement the SWIFT System has been compiled. This system represents a combination of policy changes, processing enhancements, and technological innovations.

Baggage and Passenger Screening

- We noted that during CTX baggage screening, about 22% of bags create an alarm and then occupy the x-ray machine for a significant amount of time while the appropriate response is considered. The alarmed bag will be shunted onto an “alarm-bag conveyor” with a remote video showing the alarm condition. This could increase the processing rate by about 50%.

- Regarding checkpoint processing, we found that the x-ray inspection of a passenger’s bags took appreciably longer than magnetometer screening. Using an Arena simulation model, we found that installing two x-rays per magnetometer would reduce the average delay by about 40%. Combined with the other features of the SWIFT System, the delay to all travelers is reduced still further.

- In order to expedite processing in the SWIFT enrollee lane, we recommend that the walk-through metal detector (WTMD) be set to a slightly lower sensitivity than those at non-SWIFT lanes. This will enable passengers who forget to remove small, low-risk metal objects from their pockets to pass through without setting off the alarm. A passenger who does set off the WTMD, can be permitted to remove the offending items and make a “second pass.” As a result, the time consuming secondary searches, that involve the examination of the contents of baggage or the use of a hand-held metal detector (“wanding”), are less frequent in the SWIFT lane.
SWIFT Traveler Card and Biometric Authentication

There are a number of biometric possibilities currently available for SWIFT traveler verification to ensure that the person using the card is the one to whom it was issued. The most ideal biometrics for SWIFT are finger and iris scans. Each meets our stringent false-rejection criteria, and a fused system of multiple biometric devices has a very low false-rejection rate, below 3 in 10,000. Further operational testing in an airport environment is needed to assess performance in field conditions.

Test Phase
We recommend initial testing of a SWIFT System at Pittsburgh International Airport (PIT) because of its close proximity to TSA headquarters in Washington, D.C. PIT also serves as a hub to US Airways, and thus, is not the origin airport for most of the passengers that pass-through – enabling easier testing of the SWIFT System. Similar testing at several other airports should follow. Initially, all that will be needed at the airport checkpoint will be a card scanner and biometric devices. The initial users will be airport and airline employees, followed by airlines’ preferred passengers, who will be issued the cards at no cost. Later versions of the SWIFT System will involve airlines identifying SWIFT travelers at check-in and having baggage scanned in a priority mode. Eventually, a national network will be maintained that ties together a national database of SWIFT travelers that is updated regularly by TSA and other national security agencies.

Enrollment Phase

- Since the SWIFT System is a strictly voluntary program, there is much leeway on how and what type of information is collected from enrollees. There are also few restrictions on how this information is used to determine the eligibility of a SWIFT applicant. Although TSA will have discretion over which databases are searched and what the acceptable risk thresholds might be for potential SWIFT enrollees, we presume that information about an applicant’s past countries of residence, possible criminal history, credit history, employment history, and foreign travel history be included when
determining their eligibility. Also, those applicants who already have security-level clearance with the United States government or military should be more easily enrolled in SWIFT.

• In order to make enrollment for the SWIFT System accessible to its target market of frequent business travelers, enrollment centers will be located within secure sections of participating airports. Because the SWIFT application process is likely to require an extensive amount of information, the application will be designed so that an individual can complete it while waiting at an airport, during a flight, or while at home. Enrollment centers will have the ability to capture the biometric information of new applicants as well as to renew the biometric information of existing card holders.

• Our research indicates that passengers in our target market will be willing to pay a $50 enrollment fee to participate. Our preliminary cost analyses also indicate that this amount is sufficient to offset the TSA’s costs for background checks, the system’s primary cost driver.
WORKS CITED

Bush, President George W. “Securing the Homeland, Strengthening a Nation”  

Federal Bureau of Investigation http://www.fbi.gov/hq/cjisd/nics/nicsfact.htm

“Fiscal Year 2004 Budget Briefing: PowerPoint Presentation.” Transportation Security  

“Framework for Evaluating and Deploying Biometrics in Air travel Applications:  

International Biometric Group, LLC, www.biometricgroup.com


National Institute of Standards and Technology (NIST), Information Technology  
Laboratory: Smartcard Research and Development. [http://smartcard.nist.gov/],  

Office of Management and Budget, Budget of the United States Government, Fiscal Year  
2003. (December 6, 2003)

Smart Card Alliance. Smart Card and Biometrics in Privacy-Sensitive Secure Personal  


Vanderhoof, Randy. Smart Card Alliance Newsletter, Volume 3 Number 9. Smart Card  

Vicus, W. Kip, and Richard J. Zeckhauser. “Sacrificing Civil Liberties to Reduce  
Terrorism Risks,” Harvard Law School: John M. Olin Center for Law, Economics, and Business,  
## APPENDIX A: DEMAND ESTIMATION AND SURVEY RESULTS

**Figure A.1 – PIT Survey Instrument**

<table>
<thead>
<tr>
<th>Question</th>
<th>Date:</th>
<th>Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How many commercial airline trips did you take in the past 12 months (for business or personal reasons)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Do you normally check bags on your trips? YES / NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. If yes, how many bags do you check? 1 2 3+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. If no, how many carry-on bags do you usually carry? 0 1 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. How important are the following issues when traveling:</td>
<td>Unimportant (1)</td>
<td>Very Important (5)</td>
</tr>
<tr>
<td>a. Waiting to get a ticket/boarding pass at the airline ticket counter</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>b. Waiting in security lines at the departure airport</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>c. The passenger screening process</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>d. Loss/Theft of items in checked baggage</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>e. Waiting to receive checked bags at your destination</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>f. Cost of plane tickets</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>g. Distance traveling (to determine if you would drive instead)</td>
<td>1 2 3</td>
<td>4 5</td>
</tr>
<tr>
<td>h. What is the greatest distance you would choose to drive instead of flying?</td>
<td>150 miles or less</td>
<td>150-250 miles</td>
</tr>
<tr>
<td>4. When flying commercially <strong>before</strong> September 11, 2001, how early did you normally arrive at the airport before your scheduled departure time?</td>
<td>☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>5. <strong>Today</strong>, how early did you arrive at the airport before your scheduled departure time?</td>
<td>☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>6. How long did you expect to wait today (cumulative) for the entire process (ticketing, baggage check, and finally getting through the checkpoint)?</td>
<td>☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>7. How long did you actually wait today?</td>
<td>☐ ☐ ☐ ☐</td>
<td></td>
</tr>
<tr>
<td>8. Would you be interested in a ‘registered traveler’ program that reduced your waiting time at the airport? <strong>IF NO, SKIP TO Q.10</strong> YES / NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. How much time savings do you think this system should provide you in order to be worth it?</td>
<td>10 to 30 min</td>
<td>30 min to 1 hour</td>
</tr>
<tr>
<td>10. What is the most you would be willing to pay for enrollment in a travel registration system?</td>
<td>$0 $25 $50 $75 $100 $150+</td>
<td></td>
</tr>
</tbody>
</table>
The major survey findings are as follows:

- Eighty-six percent of passengers surveyed indicated that they would be interested in a registered traveler program if it reduced their current waiting time at the airport.
- An average time savings of 45 minutes would make the registered traveler program worthwhile.
- The average price passengers would pay for enrollment in a registered traveler program is $37 (the median is $25).
- Waiting in security checkpoint lines, the passenger screening process and the cost of plane tickets were the three most important issues passengers identified when flying commercially.
- Passengers, on average, arrive 30-60 minutes earlier for flights today than before September 11, 2001.
- Sixty-five percent of respondents regularly check bags.

Chart 1 shows the distribution of passengers based on how many trips they have made in the last year. Based on the PIT survey results, the median number of flights taken last year was eight.

**Chart 1: Cumulative Percentage of Total Travelers vs. Trips Taken per Year**

In determining the SWIFT target market, it is useful to measure passenger interest based on air travel frequency. Using the PIT survey results, the analyses show that, the more often a
passenger flies, the more likely he is to be interested in a registered traveler program, and passengers traveling ten or more times per year were the most more likely to express such interest. (see Chart 2 below).

Chart 2: Passengers’ Interest in SWIFT by Travel Frequency

The time cost of delay (TDC) will obviously depend on distribution of passenger salaries and those salaries vary with travel frequency. Table 1 illustrates that more than half of frequent flyers (traveling ten time or more per year) earn over $100,000. This indicates that the TCD is higher for frequent business travelers, reinforcing the idea that reducing wait times at the airport should be an important goal of SWIFT.
Table 1: Travel Frequency by Salary Distribution

<table>
<thead>
<tr>
<th></th>
<th>$49K or less</th>
<th>$50K-$74K</th>
<th>$75K-$99K</th>
<th>$100K+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flew once</td>
<td>12.5%</td>
<td>9.4%</td>
<td>6.7%</td>
<td>4.0%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Flew twice</td>
<td>15.6%</td>
<td>12.5%</td>
<td>6.7%</td>
<td>6.0%</td>
<td>9.7%</td>
</tr>
<tr>
<td>Flew 3 or 4 times</td>
<td>18.8%</td>
<td>18.8%</td>
<td>16.7%</td>
<td>12.0%</td>
<td>16.0%</td>
</tr>
<tr>
<td>Flew 5-9 times</td>
<td>18.8%</td>
<td>18.8%</td>
<td>16.7%</td>
<td>20.0%</td>
<td>18.8%</td>
</tr>
<tr>
<td>Flew 10+ times</td>
<td>34.4%</td>
<td>40.6%</td>
<td>53.3%</td>
<td>58.0%</td>
<td>47.9%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

As the current wait times at the airport decrease, some proportion of passengers that now drive short distances will instead choose to fly. Table 2 below shows the greatest distance passengers would choose to drive instead of fly based on the current wait times experienced at the airport.

Table 2: Greatest Distance Passengers Would Choose to Drive Instead of Fly

<table>
<thead>
<tr>
<th></th>
<th>What is the greatest distance you would choose to drive instead of fly?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150 miles</td>
</tr>
<tr>
<td>Flew once</td>
<td></td>
</tr>
<tr>
<td>Flew twice</td>
<td>7.7%</td>
</tr>
<tr>
<td>Flew 3 or 4 times</td>
<td>9.1%</td>
</tr>
<tr>
<td>Flew 5-9 times</td>
<td>7.7%</td>
</tr>
<tr>
<td>Flew 10+ times</td>
<td>28.8%</td>
</tr>
<tr>
<td>Total</td>
<td>18.1%</td>
</tr>
</tbody>
</table>
Estimating Elasticity of Demand

Using ordinary least squares regression, the number of travelers willing to enroll at a given enrollment fee was regressed on how much travelers were willing-to-pay to enroll. Table 3 shows the percentage of passengers’ who are estimated to be willing-to-pay at various prices.

Table 3: Passenger Willingness-to-Pay by Travel Frequency

<table>
<thead>
<tr>
<th>How much are you WTP?</th>
<th>Travel Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0</td>
<td>29</td>
<td>21.01</td>
<td>21.01</td>
</tr>
<tr>
<td>$25</td>
<td>56</td>
<td>40.58</td>
<td>61.59</td>
</tr>
<tr>
<td>$50</td>
<td>33</td>
<td>23.91</td>
<td>85.51</td>
</tr>
<tr>
<td>$75</td>
<td>6</td>
<td>4.35</td>
<td>89.86</td>
</tr>
<tr>
<td>$100</td>
<td>10</td>
<td>7.25</td>
<td>97.1</td>
</tr>
<tr>
<td>$150</td>
<td>4</td>
<td>2.9</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>138</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Taking the natural logarithm of both variables allows for easy interpretation of the results. The regression then becomes:

\[
\ln(\text{travel freq}) = \alpha + \beta \ln(\text{WTP})^{60}
\]

(1)

Using the survey results, table 4 shows how a 20% change affects passengers making various numbers of flights per year.

---

60 Where \(\ln(travel\_freq)\) is the natural log of travel frequency and \(\ln(WTP)\) is the natural log of willingness-to-pay. \(\alpha\) is a constant term and \(\beta\) is the coefficient, both of which are to be estimated.
Table 4: How the Change in Price Affects Enrollment

For all air travelers—a 20% increase in price leads to 30% reduction in enrollment

<table>
<thead>
<tr>
<th>Price</th>
<th>Actual travelers at this price</th>
<th>% Travelers at this price</th>
<th>New Price</th>
<th>Actual travelers at new price</th>
<th>% Travelers at new price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25</td>
<td>56</td>
<td>41%</td>
<td>$30</td>
<td>39</td>
<td>29%</td>
</tr>
<tr>
<td>$50</td>
<td>33</td>
<td>24%</td>
<td>$60</td>
<td>23</td>
<td>17%</td>
</tr>
<tr>
<td>$75</td>
<td>6</td>
<td>4%</td>
<td>$90</td>
<td>4</td>
<td>3%</td>
</tr>
<tr>
<td>$100</td>
<td>10</td>
<td>7%</td>
<td>$120</td>
<td>7</td>
<td>5%</td>
</tr>
<tr>
<td>$150</td>
<td>4</td>
<td>3%</td>
<td>$180</td>
<td>3</td>
<td>2%</td>
</tr>
</tbody>
</table>

For air travelers flying less than 5 times per year—a 20% increase in price leads to 36% reduction in enrollment

<table>
<thead>
<tr>
<th>Price</th>
<th>Actual travelers at this price</th>
<th>% Travelers at this price</th>
<th>New Price</th>
<th>Actual travelers at new price</th>
<th>% Travelers at new price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25</td>
<td>19</td>
<td>42%</td>
<td>$30</td>
<td>13</td>
<td>30%</td>
</tr>
<tr>
<td>$50</td>
<td>10</td>
<td>22%</td>
<td>$60</td>
<td>7</td>
<td>15%</td>
</tr>
<tr>
<td>$75</td>
<td>2</td>
<td>4%</td>
<td>$90</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>$100</td>
<td>2</td>
<td>4%</td>
<td>$120</td>
<td>1</td>
<td>3%</td>
</tr>
<tr>
<td>$150</td>
<td>0</td>
<td>0%</td>
<td>$180</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

For air travelers flying more than 5 times per year—a 20% increase in price leads to 26% reduction in enrollment

<table>
<thead>
<tr>
<th>Price</th>
<th>Actual travelers at this price</th>
<th>% Travelers at this price</th>
<th>New Price</th>
<th>Actual travelers at new price</th>
<th>% Travelers at new price</th>
</tr>
</thead>
<tbody>
<tr>
<td>$25</td>
<td>37</td>
<td>40%</td>
<td>$30</td>
<td>26</td>
<td>28%</td>
</tr>
<tr>
<td>$50</td>
<td>23</td>
<td>25%</td>
<td>$60</td>
<td>16</td>
<td>18%</td>
</tr>
<tr>
<td>$75</td>
<td>4</td>
<td>4%</td>
<td>$90</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>$100</td>
<td>8</td>
<td>9%</td>
<td>$120</td>
<td>6</td>
<td>6%</td>
</tr>
<tr>
<td>$150</td>
<td>4</td>
<td>4%</td>
<td>$180</td>
<td>3</td>
<td>3%</td>
</tr>
</tbody>
</table>
APPENDIX B: SYSTEM FLOW DIAGRAMS

The system processes, such as enrollment and security screening, are detailed in their respective sections of the report. The following are process flow diagrams which graphically depict the enrollment and security screening processes. The top of each diagram highlights the aspect of the system functional requirements that are fulfilled by the process design. Some of the flow lay out network processes, as well as those “physical” processes that occur within the airport.
**Figure B.1: Enrollment System (1)**

**Functional Requirements Fulfilled**

1. Solicit SWIFT System Application
2. Obtain Valid Application Materials
3. Verify Applicant is Low Risk
4. Certify Applicant as System Participant

**Technical Design: Physical**

1. Interested Party Visits TSA - Operated In-Airport SWIFT Registration Stand
2. Interested Party Provided SWIFT System Marketing Material and Application Form
Figure B.2: Enrollment System (2)

The following system begins when an interested party visits the SWIFT registration stand.

Functional Requirements Fulfilled

1. Solicit SWIFT System Application
2. Obtain Valid Application Materials
3. Verify Applicant is Low Risk
4. Certify Applicant as System Participant

Technical Design: Physical

1. Applicant Submits Application Materials
2. TSA Representative Reviews Materials for Validity
3. Complete/Incomplete or Fraudulent
   - Approve
   - Deny
4. Forgery/Omission
   - Forgery
   - Applicant Exits System
5. Applicant Provides Biometric Templates
6. SWIFT Staff Builds Enrollment Record
The following system begins when an applicant’s submitted materials have been approved as valid.

**Functional Requirements Fulfilled**

- Solicit SWIFT System Application
- Obtain Valid Application Materials
- Verify Applicant is Low Risk
- Certify Applicant as System Participant

**Technical Design: Physical**

- SWIFT Staff Conducts Applicant Background Check
- Approve/Deny
  - Approve
  - Deny
- SWIFT Staff Initializes/Personalizes SWIFT Card
- Applicant Exits System

**Technical Design: Network**

- Local TSA Server
- Central TSA
- Query: Criminal Databases, Credit History, Employment History, Travel History etc.
- Central TSA Approve/Deny
- Local TSA Server
The following system begins when an applicant’s SWIFT card has been initialized by SWIFT staff.

**Figure B.4: Enrollment System (4)**

Functional Requirements Fulfilled

1. Solicit SWIFT System Application
2. Obtain Valid Application Materials
3. Verify Applicant is Low Risk
4. Certify Applicant as System Participant

Technical Design: Physical

1. SWIFT Staff Informs Applicant that Card is Ready
2. Applicant Visits In-Airport Registration Stand for Pick-Up
3. Applicant Applies “Live” Biometric for Verification
4. Approve/Deny
   - Approve
   - Deny
5. SWIFT Staff Issues SWIFT Card
6. Applicant Exits System

Technical Design: Network

Client Queries Swift Database located on local TSA server. Verifies existence of SWIFT Profile

“3-way” handshake verification process b/w biometric located on SWIFT local server, SWIFT Token, and “Live” biometrics from SWIFT Passenger
The following system begins when a participant approaches the security checkpoint at the airport.

**Functional Requirements Fulfilled**

- Verify Passenger is Program Participant
- Verify Participant’s Identity
- Verify Participant Scheduled to Fly
- Reconfirm Participant Poses Low Risk
- Permit Participant to Undergo Expedited Screening

**Technical Design: Physical**

- Passenger Swipes/Waves SWIFT Card
- Passenger Applies 1st “Live” Biometric
- Passenger Applies 2nd “Live” Biometric
- TSA Employee Receives “Green Light”
- TSA Employee Permits Passenger to Undergo SWIFT Screening

**Technical Design: Network**

- Client Queries Swift Database located on local TSA server. Verifies existence of SWIFT Profile
- “3-way” handshake verification process b/w biometric located on SWIFT local server, SWIFT Token, and “Live” biometrics from SWIFT Passenger
The following system begins as the SWIFT participant commences his/her security screen.

**Figure B.6: Security Screening System (2)**

Functional Requirement Fulfilled

- Verify Passenger is Program Participant
- Verify Participant’s Identity
- Verify Participant Scheduled to Fly
- Reconfirm Participant Poses Low Risk
- Permit Participant to Undergo Expedited Processing

Technical Design: Physical

- Participant Places Carry-On Luggage/Metal Objects on Continuous Belt
- Participant Walks Through Lower Threshold Magnetometer
- Participant Alarms X-Ray
- Participant Deemed “Cleared”
- Participant Enters Sterile Area
- Participant Alarms Magnetometer
- Participant Undergoes SWIFT Secondary Screening
- Participant Fails Secondary Search
- Participant Undergoes SWIFT Secondary Screening
- Participant Exits System
APPENDIX C: ANALYSIS OF SECURITY CHECKPOINT OPERATIONS AT PIT

Following the events of September 11, 2001, the federal government made major modifications to the security procedures at our nation’s airports. Those familiar with airport travel will recognize that carry on bags must be screened using an x-ray device, and that individuals must be screened using a walk through metal detector (WTMD). Prior to September 11, anyone was allowed into the secure side of the terminal. Additionally, individuals were allowed multiple passes through a WTMD and were cleared when they passed through the WTMD without setting it off. Small pocket items such as keys and mobile phones could be passed around the x-ray machine.

Since September 11th, many policy changes have affected the throughput of the screening area. The primary changes in security screening policy are outlined below:

- Each piece of baggage must be stopped inside an x-ray machine to be examined before it can be cleared into the secure section of the airport (airside).
- Pocket items, such as mobile phones, wallets, and keys must be X-Rayed rather than simply passed around the WTMD and handed back to the passenger.
- Only air travel employees and passengers may pass through the checkpoint.
- If an individual sets off a WTMD (perhaps due to keys in a pocket), they must go through a secondary screening procedure. Prior to the policy changes, individuals in a similar situation could simply remove the keys from their pockets and pass through the WTMD a second time.
- WTMDs are set at a more sensitive setting than prior to September 11th.

The combined effect of these policies is fourfold:

- Individuals spend less total time passing through the WTMD (as ‘second passes’ are no longer permitted).
• Each individual has more objects which must be screened using the x-ray machine (as pocket items must now be x-rayed).

• A lower number of individuals without bags pass through the checkpoint, raising the average number of bags per passenger (as non-travelers and non-employees cannot pass).

• Each individual piece of baggage requires more time to be screened in the x-ray machine (as the x-ray conveyor belt must be stopped for each piece of baggage). Furthermore, the x-ray machines currently in place were not designed for start/stop operation.

Most airports are configured using a 1:1 design. This means that each WTMD is paired with one and only one x-ray machine. TSA policy stipulates the use of a 1:1 design, but as this policy cannot be construed as impacting security, it can be more easily changed. Depending on the flow of passengers through a checkpoint, any number of 1:1 screening lanes can operate in parallel. Prior to September 11th the average time required for an individual’s WTMD screening was similar to the average time for an individual’s bags to pass through each x-ray machine. Thus, the 1:1 design was justified. Because many of the post-September 11th screening procedures were hastily implemented, many of the assumptions that went into security process design were carried over from pre-September 11th operations without taking into consideration the changes.
Figure C.1
Figure C.1 shows the differential in screening times between the x-ray device and the WTMD. The numbers were arrived at as follows: Prior to September 11th, we estimate that each bag took an average of 4.5 seconds to screen, instead of the present 6.0 seconds. Additionally, travelers were not required to remove laptops from their carry-on luggage and could pass pocket items around the machine. We believe a conservative estimate is that passengers took 0.5 less bags. This is even truer of the business traveler, who is more likely to carry a laptop, PDA, or additional pocket items. Additionally, we estimate that most (70%) passengers required a single pass through the WTMD. Furthermore, we estimate that 20% took two passes through the WTMD, and 10% required secondary screening.

Airports are generally designed in one of two ways. Most airports built or substantially modified since 1981 have a single point of entry. These include Atlanta and Pittsburgh. This means that a single checkpoint serves a number of concourses. In contrast, many of those built prior to 1981 have multiple points of entry. These airports include Philadelphia, LAX, and Newark. In these designs, a separate security checkpoint serves only one, or at most, a few concourses, and a 2:1 design would even more significantly increase speed. Security checkpoint design must first and foremost conform to the design
of the airport and TSA policies, but with slight modifications, the 2:1 design and other design changes presented in this paper would apply to numerous airport configurations.

As previously mentioned, PIT security screening consists of a single checkpoint, and the width of the available area becomes the primary constraint with respect to improved security. At present, the airport security screening checkpoint consists of seven 1:1 lanes (each x-ray is paired with one and only one WTMD), and is fit within a space that is 68’ wide. However, the Allegheny County Airport Authority has already awarded a contract for expansion of this area to 84’ in width. The remainder of this paper focuses on the best utilization of the 84’ that will be available following the building configuration modification.

Analysis of a number of alternative checkpoint designs provides insight into the best choice for airport designers. Although a purely numerical analysis would seem to justify a ratio of three x-ray machines to each WTMD, an operational analysis eliminates this option. Individuals frequently hesitate when separated from their carry-on baggage, and if their baggage were to be put on an x-ray machine not immediately adjacent to the WTMD, it would likely not be used. Thus, our design options are:

MX (1:1) The current design, in which each x-ray machine is paired with a WTMD. PIT currently has seven 1:1 lanes operating in parallel.
XMX (2:1) A potential design in which two x-ray machines are matched with each WTMD.
XMXMX (3:2) A potential design in which each WTMD has one dedicated x-ray machine, and then shares a single x-ray machine with a second WTMD.

As would be expected, single lanes (consisting of a WTMD and any attached x-rays) operating according to each of the above configurations operate at 100%, 200% and 150%, respectively, of the current design. At most airports, checkpoint space is at a premium, and is limited by the width of the corridor. Each component of the system added uses some of that corridor width. Additionally, several of the components require
operator space or free space to be adjacent to the unit to insure its proper operation (for example, x-ray machines cannot be placed within 18” of a WTMD). As such, we can examine the ‘linear efficiency’ of each design as follows:

\[
\frac{\text{SingleLaneThroughput}}{\text{SingleLaneWidth}} = \text{LinearEfficiency}
\]

We then note that the ‘linear efficiency’ of a 3:2 design is 3% higher than that of a 1:1 design, and that the ‘linear efficiency’ of a 2:1 design is 16% higher than a 1:1 design. This would at first glance seem to suggest a confirmation composed entirely of 2:1 systems operating in parallel. Unfortunately, spacing and procedural constraints often limit the effectiveness of a series composed exclusively of 2:1 systems.

Current TSA policy designates a number of travelers each day as ‘selectees’ based on the CAPPS system. Selectees must all undergo a full secondary screening process, and as such are often handled in a dedicated screening lane. Because the number of selectees is a rather low percentage of total travelers, this lane does not often require two x-ray machines in order to handle its load. Similarly, many airports (including Pittsburgh) designate additional lanes as ‘employee lanes’ and ‘priority lanes’ (for first class and frequent travelers). Each of these specialized lanes is permitted to handle coach passengers as well, but during periods of high demand they provide quicker access to the terminal to specific groups.

PIT will be undergoing renovations to increase the amount of width available for use in the security checkpoint. At present, 68’ are available, and this will be expanded to 84’. Each of the following system components occupies floor space as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Ray Machine</td>
<td>42 inches</td>
</tr>
<tr>
<td>WTMD</td>
<td>35 inches</td>
</tr>
<tr>
<td>X Ray Operator</td>
<td>35 inches</td>
</tr>
<tr>
<td>WTMD/X Ray Spacer</td>
<td>18 inches</td>
</tr>
</tbody>
</table>
It should be noted that because operators can be offset, two x-ray machines can share a single operator space. A number of configurations can be placed within the 84’ that will shortly be available at PIT:

Each of these designs would fit within the 84’ that will become available following structural modifications to the security checkpoint area.

Arena simulation software allows us to examine the performance of each design as shown below. The data presented assumes four distinct Poisson processes representing entry rates with the following statistics:

<table>
<thead>
<tr>
<th>Customer Class</th>
<th>Seconds/Arrival (theta)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selectee</td>
<td>10 sec/arrival</td>
</tr>
<tr>
<td>First Class/Priority</td>
<td>5 sec/arrival</td>
</tr>
<tr>
<td>Coach</td>
<td>3 sec/arrival</td>
</tr>
<tr>
<td>Employee</td>
<td>2 sec/arrival</td>
</tr>
</tbody>
</table>
The reason we see such dramatic results is that the WTMDs are substantially underutilized. Even in a 2:1 design, the magnetometers are utilized for only a small fraction of the time; however, designs with a higher ratio of x-ray machines to WTMDs are infeasible due to the behavior of passengers (passengers are often unwilling to put any distance between themselves and their bags).

Yet another advantage of the 2:1 design is that it allows better utilization of security personnel. Each WTMD must be staffed by at least one TSA employee. When a WTMD is underutilized, it also means that the employee staffing that particular device is also underutilized. By eliminating unnecessary WTMDs, we not only save space, we also free staff, which either reduces staffing costs (and hence security costs) or reallocates manpower to other areas of airport security.

TSA and the Allegheny County Airport Authority permitted an operational test of the 2:1 design. To conduct our test, we roped off one of the side-by-side magnetometers in the 1:1 design and continued to use two x-ray machines. Upon observation, we noticed no delays that arose from the 2:1 design. At this initial stage, we also measured checkpoint throughput per unit time, and noticed that the 2:1 lane was not quite twice as fast as a 1:1 lane. Further investigation revealed that a new ‘shoe metal detector’ was in use on the day of our test. Because standardized policies on the use of the shoe metal detectors had not yet been set, there were significant differences in operating procedures across lanes. For this reason, we chose to discount data from this particular observation.

61 Shoe Metal Detectors consist of the electronics of a ‘wand’ metal detector connected to a case. Passengers wave their shoes over the Shoe Metal Detector to determine whether or not their shoe contains metal shanks. This prevents shoes from causing ‘an alarm’ when a passenger passes through the WTMD. The day of our observation, it appeared as if the SMDs were slightly oversensitive. This caused many passengers to unnecessarily remove their shoes at the last minute. These ‘Last Minute Shoe Guys’ (LMSGs) caused bags to be spaced farther apart on the belt, in addition to adding to the number of items to be scanned. Some operators encouraged use of the SMDs more than others. This resulted in differences in the delays caused by the SMDs from lane to lane. Since this time, SMDs have been relocated, and now passengers have time to scan and remove their shoes well before they need to pass through the security checkpoint.
One potential flaw in a 2:1 design deals with WTMD downtime. As we have seen, the number of WTMDs in operation generally has little to do with checkpoint throughput. As would be expected, when a WTMD becomes inoperative in the 1:1 system, throughput is not reduced at all. A single WTMD simply does the job of two, and the lane with the inoperative WTMD operates as the 2:1 lanes described previously. If a WTMD goes down in a 2:1 design, the two x-rays normally associated with the WTMD are not immediately adjacent to any WTMDs. This prevents those x-rays from being effectively utilized and takes two x-ray machines out of service, which has a marked effect on throughput. After a WTMD is serviced, TSA policy requires that it undergo significant testing before it can be used for screening. Because peak flows through security checkpoints generally last between one and two hours in duration, this means that if a WTMD goes down during a peak period, the checkpoint will most likely need to operate without it for the remainder of the peak period. Fortunately, WTMDs are generally much more reliable than x-ray machines, but the risk still exists. One possible solution to this problem is to reposition two WTMDs in series between each set of two x-ray machines, as shown below. Both WTMDs will be powered on and will operate at all times, but only one will be used for screening. If a single WTMD goes down, the other WTMD in the lane can take over as the active device.

Using two WTMD machines per lane should not present a significant capital expense to airports beyond the cost of additional x-ray machines, because most airports already own the same number of WTMDs and x-ray machines (for the 1:1 design), and the reconfiguration would only require the purchase of a few additional x-ray machines and magnetometers.
Even if this innovation were not implemented, a highly improbable number of WTMD malfunctions would need to take place in order to render the 2:1 system slower than the status quo. The table below compares a 1:1 design with 8 lanes (Design B from the previous page) and a ‘mixed’ design (design A) which uses both 2:1 and 1:1 designs. Both estimates represent ‘worst case;’ that is, the most important magnetometer is assumed to malfunction first. The table below summarizes the number of accessible x-ray machines (AXR) and the ‘service time’ quotient (STQ), which represents the fraction by which the average service time would be reduced (over that of the ‘status quo’ of Design A).

<table>
<thead>
<tr>
<th>Number of Inoperable WTMDs</th>
<th>Design A (1:1)</th>
<th>Design B (Mixed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AXR</td>
<td>STQ</td>
</tr>
<tr>
<td>0</td>
<td>8</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>75%</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>75%</td>
</tr>
</tbody>
</table>

In all probable circumstances, the mixed design meets or exceeds the design composed entirely of 1:1 lanes. The probability of three or more WTMDs going down simultaneously is exceedingly low.

A more frequent concern with respect to malfunctioning checkpoint systems is that of inoperable x-ray machines. X-ray machines malfunction considerably more frequently than do WTMDs. This is even truer under current policy, as x-ray machines presently in service were not designed with frequent starting and stopping of the x-ray belt in mind. Because the number of accessible x-ray machines is the driving force with respect to checkpoint throughput, it is certainly advantageous to have as many x-ray machines as possible. Once again, this is accomplished in checkpoint layouts which make use of the 2:1 and 3:2 lanes.
Federal policy since January 1, 2003 dictates that the Transportation Security Administration must screen all checked baggage using either a CTX machine or an ETD (explosive trace detection). The new screening procedures have two primary disadvantages: they require a large number of TSA employees and, in airports where travelers escort their luggage through the security process, travelers experience significant delays.

These changes were implemented quickly with safeguarding security as a primary objective. In their haste, however, some simple processing enhancements that would not compromise security were overlooked. We examined the performance of the current and alternative security operations at Pittsburgh International Airport (PIT).

To determine the efficiency of the current system, we examined the mandated policies, the procedures, and their efficiency. Our studies focused on the US Airway terminal that contained only one CTX machine and 18 staffed ETD machines to handle a total of 600 bags. A CTX machine can only handle 180 bags an hour. If the CTX “alarms” a bag (the CTX detects a possibly dangerous item), a secondary search using an ETD machine must be conducted. When an ETD is used to search a bag, TSA uses a 40-40-20 breakdown. Forty percent of ETD searches must be a closed bag search. A closed bag search consists of a TSA staffer rubbing a cloth against the zippers and handles of a bag and then using the ETD machine to analyze the residue on the cloth. Another forty percent of the bags must be searched with a partial-open-bag search that consists of opening the bags and rubbing a cloth on the inside. The final 20% of bags must be searched with a full-open search. A full-open search requires TSA staff to open the bag and check the contents. A cloth is also rubbed throughout the bag and on its contents and then is placed in the ETD to ensure no explosive materials pass through security. One important policy concerning the 20% of full-open-bag searches is that when a CTX
secondary search has been completed, it also counts as a full-open search. For the rest of
the paper, these policies are taken as given and unchangeable although it is obvious that
changing the allocations in response to queue length would expedite processing.

**Measurements**

We first measured how quickly a CTX machine could clear a bag. After observing
several hundred bag searches in late January and early February 2003, we discovered
that, on average, it takes only 10 seconds for a CTX to clear a bag. This means that, in
ideal conditions, a CTX machine should search 360 bags per hour. We also found that
human delay can add an additional two seconds per bag. Sources of delay include: CTX
operators who do not quickly process cleared bags and employees stationed at the end of
the CTX who do not quickly remove cleared bags from the belt. Even with this delay, a
CTX is still capable of handling 300 bags. However, the most important delay associated
with a CTX search occurs when a bag raises an alarm. The CTX takes an average of 10
seconds to determine whether to alarm a bag. An alarmed bag, then, remains in the CTX
machine for, on average, an additional 37 seconds (as opposed to the normal two second
additional delay). This delay is caused by requiring an ETD screener to, first, look at the
CTX display and memorize where the alarm item appears within the contents of the bag.
This is done so that the employee can later find the item during the secondary search.
Since approximately 20% of bags alarm, the average processing time of the CTX
machine increases to 20 seconds from an average of ten seconds for non-alarm bags.

The next measurement concerns the length of time it takes to complete each type of ETD
search. The quickest search, ETD closed-bag, takes TSA employees an average of 56
seconds per bag. A partial bag search takes approximately 170 seconds and a complete
open-bag search takes 426 seconds to complete. A secondary search of CTX alarm bags
takes only 239 seconds, or 43% of a full-open ETD search. It is more efficacious then,
to use CTX alarmed bags for secondary screenings. Further, TSA does not consider ETD
technology as secure as CTX.

---

62 “Clear” refers to verifying that the bag contains no prohibited contents.
**Recommendations**

In order to alleviate the deficiencies we discovered in the operation of the CTX machine we investigated using a video monitor and screen capturing software to expedite the alarm bag process. In our proposed system, monitors would be installed at the CTX secondary screen stations. Screen capture software would allow CTX operators to send images of the alarmed bags to these remote monitors. We believe that this configuration would result in time saving, as secondary screeners would no longer have to walk to the monitor on the machine. Additionally, because they would no longer need to search for them from memory, finding suspicious items would take less time.

We found that Envision (the maker of the CTX) had incorporated these technologies in their new model CTX machines. However, TSA will have to buy additional equipment for their older model machines. We estimate that, if TSA buys this equipment and uses a screen capture device to save and transfer the image to another workstation, the delay from the bag staying in the CTX could be reduced from 37 seconds to less than five seconds. This timesaving greatly increases the CTX screening capacity to nearly 270 bags an hour. Although the number of bags requiring a secondary CTX search increases, the total number of employees required to screen bags decreases because the reduction in ETD screeners is greater than the increase in secondary CTX screeners.

Under the original configuration, at the peak time, 22 ETD stations are required (18 stations for regular ETD searches and four for CTX secondary searches using ETDs). When the proposed CTX machine alterations are made, only 344 bags are originally directed to ETD searches and the remaining are routed through the CTX machine. As a result, only 13 ETD stations will be needed for regular ETD searches. This saves five ETD positions. Because, under the new configuration, more bags will be routed through the CTX machine, more bags will need to undergo CTX secondary screening. Our models indicate that the amount of expected increase in CTX alarmed bags will necessitate one additional CTX secondary screener. The new configuration, then, will save a total of four screening positions.
There are two main outcomes of improving the CTX process. The most important is that more bags can undergo scanning by the most secure method available to TSA (the CTX machine). The second outcome is that fewer labor-intensive ETD stations would be required. In this example, four workstations could be eliminated each peak shift. According to our calculations, the 4 ETD stations could be eliminated per CTX for a savings of $458,000 per machine implementation\textsuperscript{63}. There are over 1,000 CTX machines staffed by TSA throughout the country. Increases in baggage screening efficiency nationwide could lead to considerable cost savings.

\textsuperscript{63} Provided there are two shifts a day, seven days a week at $25,000 salary, the elimination of four positions would save $458,000.
**BASE CASE**

<table>
<thead>
<tr>
<th>Input Data</th>
<th>Output Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTX Machine</strong></td>
<td><strong>CTX Machine</strong></td>
</tr>
<tr>
<td>Time for Clear Bag Scan</td>
<td>12.5 Sec</td>
</tr>
<tr>
<td>Additional Time for Suspect Bag</td>
<td>40 Sec</td>
</tr>
<tr>
<td>Percent of Bags Suspect</td>
<td>20%</td>
</tr>
<tr>
<td>Full Bag Suspect Search Time</td>
<td>239 Sec</td>
</tr>
<tr>
<td><strong>ETD Machines</strong></td>
<td><strong>ETD Machines</strong></td>
</tr>
<tr>
<td>Full Bag Search Time</td>
<td>426 Sec</td>
</tr>
<tr>
<td>Open Bag Search Time</td>
<td>170 Sec</td>
</tr>
<tr>
<td>Closed Bag Search Time</td>
<td>56 Sec</td>
</tr>
<tr>
<td>Full Bag Search Probability</td>
<td>20%</td>
</tr>
<tr>
<td>Open Bag Search Probability</td>
<td>40%</td>
</tr>
<tr>
<td>Closed Bag Search Probability</td>
<td>40%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>WITH VIDEO MONITORS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Data</strong></td>
<td><strong>Output Data</strong></td>
</tr>
<tr>
<td><strong>CTX Machine</strong></td>
<td><strong>CTX Machine</strong></td>
</tr>
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</tr>
<tr>
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<td>239 Sec</td>
</tr>
<tr>
<td><strong>ETD Machines</strong></td>
<td><strong>ETD Machines</strong></td>
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<tr>
<td>Full Bag Search Time</td>
<td>426 Sec</td>
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<td>Full Bag Search Probability</td>
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</tr>
<tr>
<td>Open Bag Search Probability</td>
<td>40%</td>
</tr>
<tr>
<td>Closed Bag Search Probability</td>
<td>40%</td>
</tr>
</tbody>
</table>

Continued on next page.
### CHANGE IN PERSONNEL

#### Input Data

<table>
<thead>
<tr>
<th>CTX</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Bag Load</td>
<td>91.06</td>
<td></td>
</tr>
<tr>
<td>Original Personnel Full</td>
<td>4.00 Per Shift</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bag Search</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New Personnel Based on Q</td>
<td>5.00 Per Shift</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Full Bag Search</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in Personnel</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

### Output Data

#### Personnel

| Change in Personnel | -4.39 |
| Salary of Personnel | $25,000 |
| Benefits of Personnel | $7,500 (30% of salary) |
| Personel to cover Shift | 1.26 |
| Weekend Multiplier | 1.40 Per Week (7 days) |
| Number of Shifts per day | 2.00 Per Day |
| Total Hiring per Position | 3.53 |

#### Cost

| Change in Personnel | $(503,075) Per Machine Year |
| Round Up Personnel Cost | $(573,300) Per Machine Year |
| Round Down Personnel Cost | $(458,640) Per Machine Year |

#### KEY

- Changeable
- Set by Policy
- Formula
- Based on Q M

---

Note: additional savings for capital cost due to need for less Machines
APPENDIX E: SYSTEM COST ANALYSIS

Throughout the development and analysis of the SWIFT System, we have identified many system costs and benefits. Determining the overall desirability and feasibility of the system necessitates synthesizing these findings into a comprehensive picture of the overall system value. SWIFT costs, however, should not be seen as stand-alone. Because SWIFT shares many of the same infrastructure needs as the TWIC system, it would clearly be advisable for SWIFT to piggyback on TWIC. SWIFT System costs, then, will be estimated here as the marginal cost of operating the system given the prior existence of the TWIC infrastructure. All cost estimates are approximate and apply to a SWIFT implementation at Pittsburgh International Airport.

Costs

The various system costs can be broken into two general categories: capital and ongoing expenditures. The primary capital expenditures associated with the SWIFT System will include the following equipment and supplies: biometric equipment, card printers and readers, computer hardware, computer software and bandwidth. Ongoing system costs include system staffing as well as the cost of the card and background checks.

Capital Investments

Enrollment Station Equipment

Every airport participating in the SWIFT System will need an enrollment station. Each airport enrollment stations will need, at minimum:

- 1 “client”/personal computer ($1,500)
• 2 biometric acquisition and matching devices (one for each of the selected biometrics)\textsuperscript{64}
  o finger-scan device ($300-$400)
  o iris-scan device ($2,000)
• 1 proximity card reader ($150\textsuperscript{65})
• 1 credit card terminal and printer ($400)

Additional enrollment station equipment might include:

• 1 computerized marketing and biometric update kiosk ($5,000)

The SWIFT System will also have data storage needs additional to that of TWIC. Each airport will need server capacity costing approximately $3,500 for a single server. For redundancy, however, two servers are recommended for a total cost of approximately $7,000 per airport.

Because SWIFT and TWIC share many of the same network requirements, it is assumed that SWIFT will utilize the TWIC infrastructure. There is, therefore, zero marginal cost associated with the SWIFT network infrastructure.

SWIFT profiles will need to managed as well as stored. A database management system is normally needed for this purpose. However, because TWIC and SWIFT have significant data overlap, a single database should be used for both. As a result, the marginal cost for data management set-up for SWIFT will be negligible—minor database development and possible license expansion.

\textsuperscript{64} International Biometric Group’s, “Framework for Evaluating and Deploying Biometrics in Air Travel Applications: Surveillance, Trusted Travel, Access Control.”
\textsuperscript{65} RFIDeas, Inc., www.rfideas.com
The operation of SWIFT will also require a central office. It is advisable that SWIFT and TWIC share these resources, as there is almost complete overlap between system functionalities at this level. Although the capacity of this office will need to be expanded, we will ignore the costs associated with this expansion as they will likely be absorbed by TWIC.

Checked-Baggage Handling Equipment

As described earlier, the SWIFT System offers efficiency improvements to the baggage handling process. Taking advantage of the improvements requires small capital investments in video monitors and screen capture software. Each CTX machine will necessitate approximately $2,000 for video equipment.

Security Checkpoint Equipment

To accommodate the increased demand on the TWIC security checkpoint lane, the SWIFT System converts an additional standard checkpoint lane into one that can be shared by SWIFT and TWIC members. The cost drivers associated with implementing SWIFT at the security checkpoint are:

- 1 “client”/personal computer ($1,500)
- 1 finger-scan device ($300-$400)
- 1 iris-scan device ($2,000)
- 1 proximity card reader ($150)

Operating Costs

Enrollment

---

66 RFIDeas, Inc., www.rfideas.com
The SWIFT airport enrollment centers will need to be staffed. Although staffing needs will vary with system demand, it is estimated that, at least initially, each station could be staffed by two TSA full-time equivalents (FTE). This would allow for the station to be staffed during peak hours each day. Marginal staffing costs for the SWIFT enrollment center at PIT would be approximately $114,660/year.\(^{67}\)

Because the enrollment centers will be located in the airport and the central office will be located with TWIC’s, marginal overhead costs will be negligible and assumed to be zero.

SWIFT’s primary variable costs of operation will be the costs of identification cards and background checks. The costs are estimated as follows:

- 1 contactless smartcard with 32 kilobyte storage capacity ($4)\(^{68}\) per participant
- 1 comprehensive SWIFT background check ($75)\(^{69}\) per applicant

We have calculated an estimate for the number of participants at PIT by assuming that members of our target market based out of Pittsburgh will register for SWIFT if it is available at PIT. We have calibrated our models with a peak arrival rate of 3,800 passengers and employees during two hours. Although there are actually two peaks a day at PIT, we based our calculation on the conservative assumption that there is only one peak per day. Furthermore, we have assumed that peaks only occur on weekdays.

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\(^{67}\) TSA estimates that each FTE actually requires 1.26 salaried employees in order to cover sick days and vacation. We assume that employee benefits are approximately 30% of the average salary of $25,000. The calculation is as follows: ($25,000*(1+.3)*(1.26)*2=$81,900

\(^{68}\) Gemplus International SA, [www.gemplus.com/basics/cost.html](http://www.gemplus.com/basics/cost.html)

\(^{69}\) This estimate is based on personal communication with an Office of Personnel and Management representative.
(also a conservative assumption). If we multiply one peak of 3,800 ‘departures’ per day by 260 days per year we can estimate a total of 988,000 departures through PIT per year\(^70\). Based on our model, 32% of those departures will be made by coach class SWIFT participants, 8% by priority class SWIFT participants, 45% by coach non-SWIFT passengers, 2% by priority class non-SWIFT passengers and the remaining 13% by employees. This means that 395,200 departures per year can be attributed to SWIFT passengers. If we estimate that SWIFT passengers make, on average, ten trips per year, we can deduce that there would be approximately 39,520 SWIFT participants at PIT\(^71\).

Assuming 39,520 participants, the costs of background checks and cards is approximately $2,964,000.

**Benefits**

As reiterated throughout this report, the SWIFT System’s benefit comes from three primary sources: a reduction in perceived ‘hassle’ of security screening, heightened security due to the reallocation of security resources and a reduction in passenger time spent undergoing security screening. Because of the difficulty associated with measuring the first two benefits, this section will focus on summarizing the more quantifiable system benefits.

**Enrollment**

\(^70\) By “departure”, we refer to passages through the security checkpoint.

\(^71\) 10 departures per year is a conservative estimate.
The primary quantifiable benefit accrued through the enrollment process is the fee paid by passengers to participate in the program. We have estimated that at approximately $50/person, the demand for the SWIFT System will be such that it provides the greatest benefit to participants and non-participants alike. Assuming 39,520 participants, the total amount of collected fees is $1,976,000.

Checked-Baggage Handling

SWIFT baggage handling improvements will offer PIT and airports like PIT significant savings in personnel required to screen baggage. Estimated saving per CTX machine is $458,640 per year\textsuperscript{72}. Assuming that PIT has 2 CTX machines that can benefit in this way, total savings to PIT from the improvements will be $917,280 per year.

Security Screening

The SWIFT System drives value at the security checkpoint through time savings for passengers. To reiterate, the benefits of time saved are calculated as follows: time saved * average opportunity cost of time, which, for SWIFT passengers, results in a time cost of delay of $18.00/hour. Our models have indicated that SWIFT passengers will save, on average 1.15 minutes per roundtrip. Again, assuming 395,200 of the 9,880,000 departures made from PIT during a year are made by SWIFT participants we can estimate savings in TCD to Appendix D: analysis of checked baggage operations at PIT SWIFT passengers for one year to be $1,775,625.

\textsuperscript{72} See Appendix D: Analysis of Checked Baggage Operations at PIT for details.
SWIFT passengers are not the only beneficiaries of the system. Employees and non-SWIFT passengers will save time, as well. The ATA survey estimates that the median salary for all air travelers is $50,000/year. Assuming non-SWIFT passengers will have $50,000 annual salaries, we can calculate their opportunity cost at $12/hour. This means that non-SWIFT passenger will save approximately $594,375 in TCD per year. Employees, at an assumed annual salary of $25,000 save $60,156.

Value Summary
Synthesizing these numbers results in a total system value, including capital investments and one year of operation, of $2,070,973. Costs and benefits of the system are illustrated in Figure E.1 below.
## Figure E.1: Cost Benefit Spreadsheet Analysis

### ENROLLMENT CENTER

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
</table>

#### Capital Expenditures

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client PC</td>
<td>$1,000</td>
<td>item</td>
<td>1</td>
<td>$1,000</td>
</tr>
<tr>
<td>Finger-Scan acquisition and matching device</td>
<td>$350</td>
<td>item</td>
<td>1</td>
<td>$350</td>
</tr>
<tr>
<td>Iris-Scan acquisition and matching device</td>
<td>$2,000</td>
<td>item</td>
<td>1</td>
<td>$2,000</td>
</tr>
<tr>
<td>Proximity card reader</td>
<td>$150</td>
<td>item</td>
<td>1</td>
<td>$150</td>
</tr>
<tr>
<td>Credit card terminal and printer</td>
<td>$400</td>
<td>item</td>
<td>1</td>
<td>$400</td>
</tr>
<tr>
<td>Marketing/biometric update kiosk</td>
<td>$5,000</td>
<td>item</td>
<td>1</td>
<td>$5,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Benefit</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrolment Fee</td>
<td>$50</td>
<td>participant</td>
<td>39,520</td>
<td>$1,976,000</td>
</tr>
</tbody>
</table>

#### Operating Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Card</td>
<td>$4</td>
<td>participant</td>
<td>39,520</td>
<td>$158,080</td>
</tr>
<tr>
<td>Background check</td>
<td>$75</td>
<td>participant</td>
<td>39,520</td>
<td>$2,964,000</td>
</tr>
<tr>
<td>Enrollment station personnel</td>
<td>$114,680</td>
<td>position/year</td>
<td></td>
<td>$114,680</td>
</tr>
</tbody>
</table>

**TOTAL COSTS** | **$3,245,640** | **TOTAL BENEFITS** | **$1,976,000**

**TOTAL BENEFITS-TOTAL COSTS** | **($1,269,640)**

Continued on next page.
### CHECKED-BAGGAGE SCREENING

#### COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video monitor/screen capture</td>
<td>$2,080</td>
<td>CTX</td>
<td>1</td>
<td>$2,080</td>
</tr>
</tbody>
</table>

**TOTAL COSTS** $2,080

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Benefit</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>$438,640</td>
<td>CTX/ year</td>
<td>2</td>
<td>$917,280</td>
</tr>
</tbody>
</table>

**TOTAL BENEFITS** $917,280

### SECURITY SCREENING

#### COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Cost</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client PC</td>
<td>$1,080</td>
<td>lane</td>
<td>1</td>
<td>$1,080</td>
</tr>
<tr>
<td>Finger-scan acquisition and matching device</td>
<td>$350</td>
<td>lane</td>
<td>1</td>
<td>$350</td>
</tr>
<tr>
<td>Iris-scan acquisition and matching device</td>
<td>$2,080</td>
<td>lane</td>
<td>1</td>
<td>$2,080</td>
</tr>
<tr>
<td>Proximity card reader</td>
<td>$150</td>
<td>lane</td>
<td>1</td>
<td>$150</td>
</tr>
</tbody>
</table>

**TOTAL COSTS** $3,500

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Benefit</th>
<th>Per</th>
<th>Quantity</th>
<th>Total Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coach SWIFT Participant</td>
<td>$5.56</td>
<td>person/ year</td>
<td>312,080</td>
<td>$1,724,378</td>
</tr>
<tr>
<td>Priority SWIFT Participant</td>
<td>$0.50</td>
<td>person/ year</td>
<td>83,280</td>
<td>$41,250</td>
</tr>
<tr>
<td>Coach Non-SWIFT</td>
<td>$1.48</td>
<td>person/ year</td>
<td>442,080</td>
<td>$655,208</td>
</tr>
<tr>
<td>PIT Employee</td>
<td>$0.46</td>
<td>person/ year</td>
<td>130,080</td>
<td>$60,156</td>
</tr>
<tr>
<td>Priority Non-SWIFT</td>
<td>$2.36</td>
<td>person/ year</td>
<td>20,840</td>
<td>$60,833</td>
</tr>
</tbody>
</table>

**TOTAL BENEFITS** $2,430,933

### COMBINED BENEFITS-COSTS

**TOTAL BENEFITS-TOTAL COSTS** $2,427,333

**COMBINED BENEFITS-COSTS** $2,070,973

*Assumed 5 flying days/week or 260/year
* *Rounded up*
APPENDIX F: TEST PILOT DESIGN

The following tables and text describe the SWIFT test process in greater detail. Table F.1 lays out all five test phases and indicates the various components and specifications associated with each. The table is supported by descriptive text which can be found following the table. In electronic form, elements of the table will also link to the detailed support text.
### Table F.1: Pilot Phases, Components and Specifications

<table>
<thead>
<tr>
<th>SWIFT Features</th>
<th>Phase I-A T=0</th>
<th>Phase I-B T+60 Days</th>
<th>Phase II-A T+5 Months</th>
<th>Phase II-B T+1 Year</th>
<th>Phase III T+2 Years</th>
<th>Major Questions to be Addressed and Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eligible Population</strong></td>
<td>Employees</td>
<td>Employees</td>
<td>Top Frequent Flyer Programs</td>
<td>Frequent Flyer Programs</td>
<td>US Passport Holders</td>
<td>% of Eligible Population Voluntarily Enrolling by Trip Frequency</td>
</tr>
<tr>
<td><strong>Application Center</strong></td>
<td>Integrated with Employee Processes</td>
<td>Non-Sterile Airport Area</td>
<td>Non-Sterile Airport Area</td>
<td>Non-Sterile Airport Area</td>
<td>Non-Sterile Airport Area</td>
<td>Staffing Requirements for Center</td>
</tr>
<tr>
<td><strong>Fee</strong></td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$50</td>
<td>$50</td>
<td>Demand Elasticity</td>
</tr>
<tr>
<td><strong>Background Check</strong></td>
<td>None Further</td>
<td>None Further</td>
<td>SWIFT Security Check</td>
<td>SWIFT Security Check</td>
<td>SWIFT Security Check</td>
<td>Staff Required to Conduct Background Check</td>
</tr>
<tr>
<td><strong>ID</strong></td>
<td>TWIC</td>
<td>TWIC</td>
<td>SWIFT Card</td>
<td>SWIFT Card</td>
<td>SWIFT Card</td>
<td>User Satisfaction, Delays Caused by Card Use, Service Rates, Durability</td>
</tr>
<tr>
<td><strong>Card Reader and Control Panel</strong></td>
<td>Card Reader</td>
<td>Card Reader</td>
<td>Card Reader</td>
<td>Card Reader</td>
<td>Card Reader, Control Panel</td>
<td>Downtime &amp; Service Rate</td>
</tr>
<tr>
<td><strong>Biometric Screening</strong></td>
<td>2 Biometric “or” System</td>
<td>FUSED System</td>
<td>FUSED System with Backup</td>
<td>FUSED System with Backup</td>
<td>FUSED System with Backup</td>
<td>Reliability, User Reactions, Delays Caused By Biometric Use</td>
</tr>
<tr>
<td><strong>Biometric Encoding</strong></td>
<td>Iris, Face, Fingerprint</td>
<td>Iris, Face, Fingerprint</td>
<td>Iris, Face, Fingerprint</td>
<td>Iris, Face, Fingerprint</td>
<td>Iris, Face, Fingerprint</td>
<td>Reliability, Failure to Enroll Rates</td>
</tr>
<tr>
<td><strong>Database and Network</strong></td>
<td>Local</td>
<td>Local Database + National Network</td>
<td>Daily Download + National Network</td>
<td>Daily Download + National Network</td>
<td>Daily Download + National Network</td>
<td>System Reliability and Security</td>
</tr>
<tr>
<td><strong>X-Ray Screening</strong></td>
<td>Stop-Belt</td>
<td>Continuous Belt</td>
<td>Continuous Belt</td>
<td>Continuous Belt</td>
<td>Continuous Belt</td>
<td>Average Time Per Bag</td>
</tr>
<tr>
<td><strong>Magnetometer</strong></td>
<td>Current</td>
<td>Second Pass</td>
<td>Second Pass</td>
<td>Lower Threshold + Second Pass</td>
<td>Lower Threshold + Second Pass</td>
<td>Decreased Service Time + Secondary Screen Staff Requirements</td>
</tr>
<tr>
<td><strong>Ticket Integration</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>Barcode</td>
<td>Barcode</td>
<td>Electronic Boarding Pass</td>
<td>Barcode Errors, System Integrity</td>
</tr>
<tr>
<td><strong>Dedicated Lanes</strong></td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1-2 as Necessary</td>
<td>1-2 as Necessary</td>
<td>Queue Length</td>
</tr>
<tr>
<td><strong>Baggage</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>Lowest Priority for CTX</td>
<td>Lowest Priority for CTX or Possible Bag Shunt</td>
<td>Lowest Priority for CTX or Possible Bag Shunt</td>
<td>Bag Screen Rate &amp; Alarm Rate</td>
</tr>
<tr>
<td><strong>Fixed After Phase Completion</strong></td>
<td>None</td>
<td>Card Technology, Card Encoding, Choice of Biometrics Technologies Chosen</td>
<td>Security Check Procedure</td>
<td>Adaptations as Necessary</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>


**Document F.1: Detailed Descriptions of Components and Specifications**

**Eligible Population:**

**Employee** - Employees of TSA, the airlines, and airport service personnel who have already received security clearances are eligible to participate. Because these individuals have already undergone a security screening, which gives them special access to the airport, no further background check is needed.

**Top Frequent Flyer Programs** - Passengers who are US citizens and belong to an airline’s highest priority club (e.g. flying over 100,000 miles annually) are eligible to voluntarily apply for SWIFT enrollment. Limiting initial participation to those citizens who are already recognized by the airlines as top frequent flyers enables TSA to more quickly and cost-effectively complete the necessary background checks. The application fee is waived at this stage.

**Frequent Flyer Programs** - Passengers who are US citizens and belong to a frequent flyer priority group are eligible to voluntarily apply for SWIFT enrollment. The application fee is still waived.

**US Citizens** - All US citizens with a passport are eligible to voluntarily apply. All applicants are required to use a credit card in their name to pay a $50 fee that covers the cost of the SWIFT card and the mandatory background check.

**Measurement** - It is important to know the size of the eligible population and what percent of that population enrolls in the SWIFT System, and how that enrollment rate varies with population characteristics like annual number of trips, age, gender, average delays at home airport, and perhaps credit history and income level. Possible system characteristics to be measured include:

- Use a survey to help determine barriers to entry in order to increase enrollment
- Assess elasticity of demand with respect to enrollment fee
- Use a survey to help determine overall user satisfaction and concerns

**Enrollment Center:**

**Employee Center** – The Employee Center builds on existing TSA infrastructure. For instance, TSA already collects fingerprints from their job applicants and screens those against a
national criminal history database. The SWIFT System could also use this capability; however, iris and facial recognition devices would need to be installed. The data would be saved on a local database and perhaps on the card, as well.

**Non-Sterile Airport Area** - Staffed by TSA employees during non-peak hours, the center is responsible for enrolling the eligible population. The center needs to be in operation prior to the implementation of Phase II-A. The center collects applications and biometric information to be stored in a database. After SWIFT headquarters conducts the preliminary background check, a card is sent to the center to be picked up by the applicant. The applicant then submits their biometrics again to be saved on the SWIFT card. By collecting the biometric data at two different periods, the possibility of cards being forged by an employee decreases. The application center is also responsible for re-enrolling individuals whose biometrics may have changed.

**Measurement** - Minimizing cost of the enrollment process and protecting secure information is vital to the SWIFT System. Possible system characteristics to be measured include:

- Need to hire additional TSA employees
- Security of the information
- Use a survey to determine the users’ acceptance of the application process

**Background Check:**

**Risk Assessment Process** – TSA will be responsible for establishing the risk criteria and thresholds. Social security number will likely be a primary identifier. Likely risk assessment sources include past countries of residence, criminal history, motor vehicle reports, credit reports, travel history, educational and professional licensing verifications, and prior employment verification. SWIFT enrollment denials and appeals are handled by TSA.

**Measurement** - The cost, timeliness, and update ability of a SWIFT security check are essential factors in determining the security of the SWIFT System. Possible system characteristics to be measured include:

- Reliability of information acquired from each database
- Ability to update database in real-time
- Political response to the introduction of a SWIFT System for public use
**ID:**

**SWIFT Card** - A SWIFT card must, at a minimum, conform to the following specifications:

- Comply with the National Institute of Standards “Government Smart Card-Interoperability Specification” (GSIT)
- Contain a microcontroller (MCU) with the following features:\footnote{Much of the following section derived from “Secure Identification Systems: Policy and Technology Choices for a Privacy-Sensitive Solution” by Randy Vanderhoof, Executive Director of the Smart Card Alliance. Source: http://www.automatedbuildings.com/news/dec02/articles/smtcrd/smtcrd.htm}
  - Sufficient data storage capacity
    - Able to hold the biometric templates for the three chosen technologies. The below table outlines the data requirements for various biometric choices.

<table>
<thead>
<tr>
<th>Biometric</th>
<th># of Bytes Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finger-scan</td>
<td>300-1200</td>
</tr>
<tr>
<td>Finger geometry</td>
<td>14</td>
</tr>
<tr>
<td>Hand geometry</td>
<td>9</td>
</tr>
<tr>
<td>Iris recognition</td>
<td>512</td>
</tr>
<tr>
<td>Face recognition</td>
<td>500-1000</td>
</tr>
<tr>
<td>Signature verification</td>
<td>500-1000</td>
</tr>
<tr>
<td>Retina recognition</td>
<td>96</td>
</tr>
</tbody>
</table>

- Able to hold additional data items such as:
  - Alphanumeric files: name, identification number
  - Security functions
    - Encryption
    - Hash functions
    - Tamper-resistance functions
  - Plus the operating system
- Read and write capability
- Data transfer rate > 50kb/second
o Contact-less capability (MCU compatible contact-less card technologies are defined by ISO/IEC 14443\textsuperscript{74})
o Security design features such as:
  ▪ Digital photo
  ▪ Hologram/watermark
  ▪ Fine line printing patterns

TWIC - A TWIC card must, at minimum, conform to the same specifications as the SWIFT card. The TWIC card, however, will likely have the following additional functionalities:
  • Contain a microcontroller (MCU) with the following features\textsuperscript{75}:
    o Increased data storage capacity
    o Able to hold additional data items such as:
      ▪ Various authorizations and multiple levels of clearance
  • Provide hybrid capabilities (ISO/IEC 14443 dual-interface cards include a single chip that provides both contact and contact-less capabilities) that will allow for interoperability between systems. Additional functionalities may, depending on need, include:
    o Magnetic stripe
    o Barcode
    o Wiegand strips
    o Barium ferrite
    o 125 kHz technology

Measurement - Preventing counterfeit cards while maintaining a quick and reliable data transfer is essential to the success of a SWIFT System. Possible system characteristics to be measured include:
  • Speed of the data transfer rate
  • Reliability of the data transfer
  • Number of security features contained on the SWIFT card


\textsuperscript{75} Much of the following section was derived from Vanderhoof. See Note 1
• Counterfeit potential
• Durability

*Card Reader and Control Panel:*

**Card Reader** - Both the TWIC and SWIFT Systems should incorporate the following capabilities:

- Responses to an invalid card may include:
  - No unlock code sent to the controller
  - Signal sent to have the reader emit a different sound, signaling that access was denied
  - Notification and activation of other security systems, such as alarms, indicating that an unauthorized card is being presented to the system

- Capable of data analysis
- Read range of at least 3 inches
- Supports MCU chip type
- Hybrid card capability

**Control Panel** - Both the TWIC and SWIFT Systems should incorporate the following capabilities:

- Provides central communication and power supply to readers
- Connects with electro-mechanical door strike and/or various alarms
- Connects with host computer
- Contains complete data format information

**Measurement** - While most, if not all, SWIFT biometric and card checkpoints will be in controlled weather conditions, some applications of a TWIC card may require readers to be in varied weather conditions. Possible system characteristics to be measured include:

- Field conditions (temperature, humidity, traffic volume, static electricity, etc.) effect on the components’ reliability
- Component failure rates

---

**Biometric Screening:**

2 **Biometric “or” System** – An “or” architecture allows for use of off-the-shelf commercial systems. Users are expected to pass one of the two systems in a primary/secondary fashion – the passage of both would be too prohibitive, especially at this early stage. This phase allows for the real-world performance testing of multiple systems without incurring the integration costs and set-up demands of a fused system.

**Fused System** - The integration of multiple biometric systems allows for the greatest gains in their joint operation. This could be, either a custom user interface and approval system operating on top of two commercial biometric packages, or, depending on market developments, a joint product (such as Identix with Finger/Face and the Partnership of Iridian and Sagem with Iris/Finger). Benefits of a fused system include a reduction of both false positive and false negative alarms. A fused system also increases the ability of persons without one biometric characteristic (e.g. due to genetics, accidents, surgery, etc.) to use the system. For example, a secure system with a single biometric would necessitate a 99-100% match; a secure fused system could allow a 95% match given that the user is required to pass through both.

**Fused System with Backup** - A third biometric that is used in case of component failures.

**Measurement** - The accuracy of any biometric system is integral to system security and the reduction of hassle for SWIFT passengers. Possible system characteristics to be measured include:

- Biometric screening acceptance by users
- False positive and false negative rates for various biometric combinations
- Processing rate for each biometric combination
- Impact of environmental conditions on each biometrics’ reliability

**Biometric Encoding:**

**Specifications** - False Acceptance/Rejection rates (FAR) of 0.1%-0.2% and Failure to Enroll Rates (FER) of 1-2%.

**Iris** - Iris scan biometric technology employs a template derived from the unique patterns inherent in the iris that is captured using infrared illumination. Both irises can be used.
The technology offers a very high degree of accuracy and unparalleled stability, but is subject to higher costs and some user reservations. Iridian is presently the only market provider.

**Face** - Facial recognition technology employs a template created from video or multiple still images of a user’s facial data. The technology is software-specific, but can employ any form of image capture equipment. There are multiple market providers. Other advantages include: near universal enrollment and the ability to run searches of derogatory databases. A primary disadvantage is that false acceptance and rejection rates are unproven in conditions under which the user’s physical presentation (e.g. facial hair and weight) and environment are unstable.

**Fingerprint** - This technology, which makes use of the uniqueness of human fingerprints, makes up the majority of the biometrics market. It uses one of three different approaches: optical, silicon, and ultrasonic imaging. The fingerprint is a well-known and accepted identifier that can leverage multiple fingers with fairly high resistance levels and good stability.

**Hash Function** - By using an algorithm to store part of the biometric information on the card and part of the information in a database, a hash function adds another level of security. This is also known as a three-way handshake.

**Measurement** - Accurate and unique encoding of biometric ensures system integrity. Possible system characteristics to be measured include:

- Memory required to save the encoded biometric
- Uniqueness of the biometric characteristics among SWIFT enrollees
- Employee access to the biometric information

**Database and Network:**

**Local Phase 1A** - Computing requirements: The initial system will consist of a stand-alone PC connected to a biometric reader. The PC must, at minimum, have:

- Monitor
- Fiber optic NIC
- 10/100 BaseT NIC
- CD/DVD ROM Drive
• Two USB 2.0 interface ports
• 512MB RAM
• Internet Explorer.

There are no network needs during Local Phase 1A.

Local Phase 1B - Computing requirements: Local Server for PIT

• 1 Server
• Total memory capacity of at least 10 Gigabytes
• Back-up server with comparable processing power and features.
• If the decision is made to use Iridian biometric software for Iris Scan verification and select their “KnowWho” Authentication Server the specs listed below are the minimum requirements.
  o Dual-processor Pentium® II PC running at 400 MHZ or greater, with 256 MB RAM or greater
  o CD-ROM drive
  o 3 Ultra-wide SCSI disks, which are 9 GB with an average seek time of less than or equal to 9 ms, and an average latency of less than 3 ms in a RAID 5 configuration.
  o Compatible operating systems
    ▪ Windows® NT Server 4.0 with service pack 5 installed
    ▪ Windows® 2000 with service pack 1 installed
    ▪ Windows® 2000 Advanced Server

• Mid-level database software

Network Phase 1B – During Phase 1B, fiber-optic connectivity will be established at the TSA checkpoint; a server will be acquired to serve as the main connector between PIT and Central TSA; connection between PC’s located at the checkpoint and the local server will be established; and TSA employee biometric data will be loaded onto the local database.

Daily Download - Local TSA will download and store the profiles of the next day’s travelers. The download will be conducted between the hours of 12AM-5AM. Downloading during off-peak times will enable TSA to negotiate lower prices with Internet Service Providers (ISP). Central TSA will be responsible for fielding the requests from local TSA sites around the country. Incoming requests for profiles should be distributed evenly
through the server cluster by a load balancing server. Service level agreements should be negotiated with several ISP’s for redundancy purposes to establish the TSA virtual private network (VPN).

- Routers
  - VPN capability
  - Fiber optic connectivity
  - Encryption

- Server
  - Clustered hardware configuration

- Database Software
  - Data warehousing
  - Enterprise class
  - Clustering capability

- Storage Area Network
  - Total memory capacity of at least 30 Gigabytes

**Measurement** - A database and network system must be able to distribute information quickly and accurately but must prevent hackers from accessing secure information. Possible system characteristics to be measured include:

- Information transfer rate
- Decisions on employee access to system and network
- System’s ability to detect and survive cyber attacks
- Frequency of system failure

**X-Ray Screening:**

**Stop Belt** - This phase continues the current x-ray policy. The belt stops for each item so that it can be manually “cleared” or “alarmed” by the operator. “Alarmed” items require a secondary search.

**Continuous** - If the operator determines that an item being x-rayed is “cleared”, then the belt does not stop. If the bag cannot be cleared while the belt is moving, however, the operator stops the belt. The operator then “clears” or “alarms” the item. “Alarm” items will require a secondary search. A continuous belt improves the processing rate.
Measurement - The throughput of the security checkpoint is essential for increasing user acceptance of the SWIFT System and increasing airport security. Possible system characteristics to be measured include:

- Throughput of the current system
- Throughput of a SWIFT System
- Staffing needs of the checkpoint
- Percentage of SWIFT and non-SWIFT travelers receiving a secondary search

Magnetometer:

One Chance – This is the current situation. Individuals are given only one opportunity to pass through a magnetometer. If the magnetometer alarms, the individuals automatically undergoes a secondary screening.

Second Chance - Individuals are given a second opportunity to pass through a magnetometer if they alarm the machine. This allows individuals who forget about a metal object to place that upon the belt and pass through the magnetometer again. If the individual alarms the second time, the person undergoes a secondary search. This allows secondary screeners to focus their energy on those passengers who pose the greatest risk.

Second Chance & Lower Probability of Alarm - This process operates in the same manner as “second chance” (above). In this case, however, the alarm threshold on the magnetometer is reduced slightly.

Measurement - The throughput of the security checkpoint is essential for increasing user acceptance to the SWIFT System and increasing airport security. Possible system characteristics to be measured include:

- Current system throughput
- Throughput of a SWIFT screening
- Staffing needs of the checkpoint
- Determine percentage of SWIFT and non-SWIFT travelers who receive a secondary search

Ticket Integration:
Bar Code - A bar code provides a more secure method of indicating a passenger’s flight status and risk assessment than the “S” currently typed on a selectee’s boarding pass. The bar code could, for example, contain information regarding the type of search TSA mandates for the passenger. While SWIFT passengers are less likely to receive a selectee search, in some circumstances, passenger characteristics and/or randomness in the system will mandate that a SWIFT passenger receive a selectee search.

Boarding Pass - In an ideal system, SWIFT passengers without bags will check-in and go through security at the same time. After submitting biometrics for identification and verification, a pass/fail message confirming the biometric match and the type of search will appear on the computer screen. At the same time, a boarding pass is printed for the passenger. This will further decrease the time needed for SWIFT passengers to check-in and pass security measures.

Measurement - By encoding a security level on the card, the passenger no longer knows what security inspection to expect and it is more difficult to forge a boarding pass. Possible system characteristics to be measured include the reliability on the barcode system.

Baggage:

CTX Probability - The greatest concern for security demands that CTX machines screen all baggage. However, the current high demand on a limited number of machines makes this impossible. In this phase of the project, when CTX machines cannot handle the flow of baggage, SWIFT passenger bags take priority in being redirected toward other search methods, such as ETD machines. Because ETD machines are slightly less secure and SWIFT passengers are somewhat less-suspect, non-SWIFT bags continue to be searched by a CTX machine. This is a more secure process than the process currently in place.

Separate Baggage Check-in - A future benefit for enrolling into SWIFT might include a separate baggage check to help reduce the overall check-in time. This separate check-in will require the cooperation of the airlines and is not essential to the success of the SWIFT System.

Measurement - Maximizing CTX machines on non-SWIFT bags will maximize security. Possible system characteristics to be measured include:
- Percentage of bags not screened by CTX either because of the size the bag or the quantity of bags
- Determine if screening the SWIFT bags require a 40-40-20 breakdown of ETD searches
- Determine alarm rate differences between SWIFT and non-SWIFT passengers
- Determine time saved by SWIFT passengers using a separate check-in
- Determine TSA’s costs associated with having a separate check-in