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SIMULATION'S ROLE IN BAGGAGE SCREENING AT THE AIRPORTS: A CASE STUDY

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ABSTRACT

The Aviation and Transportation Security Act passed by Congress in November, 2001 required the nation's airports to perform 100% checked baggage screening by December 31, 2002. To determine the impact of this requirement on its operations, Lambert St. Louis International Airport (STL) requested TransSolutions to evaluate the equipment and facility requirements to meet 100% checked baggage screening for all airlines serving STL. Discrete event simulation models were developed to evaluate passenger service levels for each alternative option considered, relative to the airport performance metric that 95% of all passengers in the peak hour would wait no longer than additional 10 minutes for baggage screening. Various protocols with different machine requirements were tested, and the "Drop-and-Go" option was chosen as the most viable alternative. This paper discusses how simulation was used to help the airport's decision making process.

1 INTRODUCTION

After the September 11th terrorist attacks, traveling public became more aware of the fact that not all checked baggage was screened by Explosive Detection Systems (EDS). Airlines used a computer profiling system, known as the Computer-Assisted Passenger Pre-screening System (CAPPS), to select those passengers who pose the greatest threat and whose baggage should be subject to a more rigorous inspection. However, since most passengers did not fit the computer profile, most checked baggage was not subject to examination by an EDS machine. On November 19, 2001, Congress passed the Aviation and Transportation Security Act requiring the nation's airlines to perform 100% checked baggage screening at all airports by December 31, 2002 (Transportation Security Administration, 2003).

The Transportation Security Administration (TSA) is putting cutting-edge electronic detection and imaging equipment in all commercial airports to identify potentially dangerous objects on passengers and in baggage. Such equipment includes (Boeing, 2003):

- InVision CTX EDS machines use technology derived from medical Computed Tomography (CT) to quickly locate and identify explosive devices concealed in checked baggage. As the conveyor moves each bag through the machine, the system produces a scan projection X-ray image. From this image, the system determines which areas need "slice" images taken by the rotating X-ray source.
- L-3 produces an EDS utilizing a dual energy computer tomography X-ray system. The eXaminer 3DX 6000 utilizes a CT image of the entire bag or parcel, which is automatically analyzed and displayed in either a 2-D or 3-D image.
- Explosive Trace Detection (ETD) machines are highly sensitive devices to detect various types of commercial and military explosives. ETD machines work in conjunction with other techniques in order to provide a comprehensive program to screen for explosives. ETD machines utilize identical separation and detection technologies used in advanced forensic laboratories worldwide.

Lambert St. Louis International Airport (STL) requested that TransSolutions determine the equipment and facility requirements to meet the 100% checked baggage screening requirement for all airlines serving STL. The feasibility of lobby solutions was studied. This is an interim option of placing EDS equipment in terminal ticket counter lobby areas to meet the December 2002 deadline until a permanent inline baggage screening system is installed.

The overall goal of this study was to determine how to best meet the operational needs while ensuring that the 100% checked baggage screening requirement would be met. TransSolutions' responsibilities included the following:

- Develop performance measures for allocating equipment and human resources.

- Forecast passenger and baggage demand.
- Determine the impact of each baggage screening option to airport operations.
- Quantify the trade-offs in equipment and human resources for different baggage screening options (e.g., quantify how the choice of stand-alone, pre-ticketing, post-ticketing, “drop-and-go”, or other configurations impact requirements at STL).
- Determine the amount of equipment and human resources needed at each terminal.

2 APPROACH

The objective of this study was to provide a detailed evaluation of the passenger and baggage flow at the curbside check-in and ticket counters, and lobby security functions such as EDS and/or ETD processing. Although many operations research techniques such as linear/integer programming, stochastic programming, and queuing theory provide valuable insights, they often fail to represent large-scale problems that arise in airport terminal design due to poor scalability or excessive computational burden. TransSolutions chose to use discrete event simulation modeling as the major tool in addressing the requirements.

Each baggage screening area within the terminal is different with respect to physical layout and operational policies, therefore, standard formula based estimators are not adequate to predict the requirements. Each airport can use the same general approach, but not the same formula because each of the airports may have a different layout, market and operating structure. To understand these differences, we must understand:

- The type of airline service.
- Seasonality impacts.
- Passenger and baggage volume.
- Time pattern of demand.
- Size of bags.

These elements help to determine baggage and passenger demand that is subject to baggage screening.

When looking at various solution scenarios as a whole, the team first and foremost kept in mind that the final choice had to be, from the passenger’s perspective, virtually seamless. Criteria included making sure TSA’s protocols and requirements were being followed and avoiding interference with time sensitive airline operations.

TransSolutions was charged with assessing STL’s requirements for EDS primary and secondary screening equipment as well as the facilities. The team selected STL’s August 2002 schedule to estimate the EDS requirements.

The following data was obtained and/or collected:

- Flight schedule – includes departure times, equipment type, and market for each airline.
- Load factor – refers to the ratio of seats occupied to total seats on the aircraft. Load factor fluctuates significantly based on the market and time of day.
- Originating and Departing (O&D) percentages – percentage O&D refers to the ratio of passengers who originate their travel in STL to the total passengers on a flight. The O&D percentage fluctuates significantly based on the market and time of day. Usually, the O&D ratio is highest in the morning.
- Passenger arrival characteristics – refers to the time passengers arrive to the airport. Factors that impact how passengers arrive to the airport: time of day and airline.
- Passenger group size.
- Number of checked bags per passenger group.
- Ticket counter and curbside check-in processing times and percentage split.
- EDS primary and secondary processing times and failure rates.

Once all data were obtained, we processed the data to generate STL passenger and baggage volumes. The process consisted of the following steps:

- Applying the load factor to the equipment capacity of each departing flight in the schedule.
- Estimating the number of originating passengers on each departing flight by applying the O&D percentages to the departing flight load.
- Estimating the number of bags per flight by applying the market-dependent checked bags per passenger group distributions to the number of O&D passengers on each departing flight.
- Applying the passenger arrival curves to the passenger groups and determining passengers’ arrival times to the airport.

The data files created through this process were used as input to our simulation models of the facilities for the different baggage screening solutions. EDS machines were added until 95% of the bags within the peak hour completed the checked baggage screening process in 10.0 minutes or less.

3 RESULTS

Many different screening options were considered and the project team ultimately recommended use of a “Drop-and-Go” option for baggage screening at the lobby. In reaching this conclusion, simulation played a significant role through “what-if” scenario analyses. The option includes EDS and ETD machines placed in the lobby and at the curb. Passengers drop their bags for baggage screening and leave. Only profiled passengers wait with their bags until screening is complete. Bags are selected for EDS screening as long as there is available queuing space and bag wait time in the queue does not increase significantly. The rest of the bags are selected for ETD screening. For some airlines, bags are placed on the baggage sortation system input belt directly upon completion of bag screening. For other airlines, bag runners take bags to carts assigned to individual airlines that have been pre-staged behind the baggage screening area. Bags wait on the cart until the cart is full or for a maximum of five minutes. Carts are taken to the airline's bag input belt. The study found that waiting until the cart is full results in unacceptably long processing times and that carts should be taken to the airline's bag input belt frequently based on bag wait time on the cart.

TransSolutions used the following decision criteria to assess EDS and ETD machine requirements and facility sizing:

- The incremental time spent in the check-in hall due to baggage screening for all bags should be no more than 10 minutes for 95% of the bags during the peak hour.
- The incremental time spent in the check-in hall due to baggage screening for all bags should be no more than 20 minutes for 100% of the bags.
- The queues must fit within the available space allocated for queuing.

STL has eight baggage screening areas. Some of these areas are dedicated to one airline and the others are cross-utilized between airlines. In this paper, we focused on one baggage screening area (Lobby Area 1) that is cross-utilized by five airlines.

Estimated equipment requirements based on the simulation model outputs are reported below. Note that the equipment requirements depicted in the following table are based on the airline groupings and other key assumptions contained in the simulation model. Changes in the terminal configurations, operating characteristics, airline locations, passenger queue areas, and other considerations may affect the resulting requirements and the ability to accommodate these requirements. Adjustments to the amount of equipment allocated to the terminal may be necessary to provide an efficient and effective screening process.

Table 1 and Table 2 summarize the performance of the Drop-and-Go option for the Lobby Area 1.

- The queue requirements are given in Table 1. Note that CAPPS passengers wait with their bags for completion of baggage screening.
- Time spent at ID check queue during the peak hour is negligible (<1.0 minute).
- Bag wait time on the accumulating conveyor is less than 1.8 minutes for 95% of the bags during the peak hour.
- The maximum wait time criterion of 20.0 minutes is not satisfied.
- Carts are sent out to the baggage belt as soon as they are full or every five minutes, whichever condition comes first.

Table 1: Performance of the Drop-and-Go Option (Queue Statistics)

Area	No. of ID Checkers	No. of EDS	No. of Primary ETD Agents	No. of Sec. Agents	Max. No. of Passengers		Max. No. of Bags		
					ID Check	CAPPS[1]	Level 1 ETD	Level 1 EDS	Level 2 ETD
Lobby Area 1	4	2	10	4	8	14	17	2	10

Notes:
[1] Includes the passengers waiting for the completion of bag screening.

Table 2: Performance of the Drop-and-Go Option (Wait and Process Time Statistics)

Area	Airline	Wait and Process Time in the Lobby during the Peak Hour (in min.)														
		Passenger Wait Time for Baggage Drop-off (ID Check Time)[1]			Bag Wait Time On EDS Belt[2]			Bag Wait + Process Time for Screening[3]			Bag Wait Time until Cart is Full or Cart is Sent out Every Five Minutes[4]			Overall Bag Wait Time until Placement on Belt[5]		
		85th Perc.	95th Perc.	Max	85th Perc.	95th Perc.	Max	85th Perc.	95th Perc.	Max	85th Perc.	95th Perc.	Max	85th Perc.	95th Perc.	Max
Lobby Area 1	1	0.0	0.0	0.4	1.4	1.8	9.7	3.3	7.2	22.7	4.2	4.7	5.0	9.2	12.2	19.1
	2										4.0	4.6	5.0	9.1	12.6	23.2
	3										4.2	4.7	5.0	8.7	11.0	16.3
	4										4.1	4.6	5.0	8.3	11.8	16.6
	5										4.1	4.7	5.0	8.3	11.0	16.2

Notes:
[1] Includes the passenger wait time in the ID check queue. Does not include the process time.
[2] Includes the bag wait time on the EDS belt. Does not include the process time.
[3] Includes the bag wait time for the ID check, on the EDS belt, in front of the primary and secondary ETD agent, EDS/ETD processing time and secondary ETD processing time.
[4] Includes the bag wait time on the cart until the cart is full or the next scheduled cart arrives (cart arrives every 5 minutes).
[5] Includes Footnote 3, Footnote 4 and time spent for the loaded cart porter time to the bag input belt.

- 95% of the bags are put onto the baggage belt in less then 13.0 minutes. This includes the wait times for the ID check, on the EDS belt, for the EDS/ETD processing and for the cart, and time spent for the loaded cart porter time to the bag input belt. Therefore, the airlines must change their cut-off time from 30.0-35.0 minutes to 43.0-48.0 minutes.

Due to the limited throughput capacity with high false alarm rates, EDS machines may not be adequate to serve the peak demand. The percentage of bags screened using EDS during the peak hours drops significantly. This result prompted the design team to consider using ETD as a backup. Figure 1 shows that Lobby Area 1 uses a maximum of 10 primary ETD agents throughout the day.

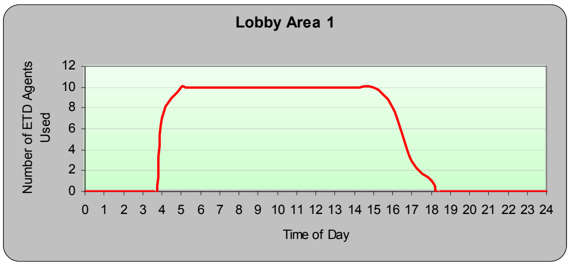

Figure 1: ETD Utilization throughout the Day

Figure 2 shows the number of active cart runners by time of day in the Lobby Area 1. Carts are sent to the baggage belt as soon as they are full or every five minutes, whichever condition comes first. There are at most seven cart runners at any one time in the Lobby Area 1. As seen from the graph, five cart runners are needed for most of the day.

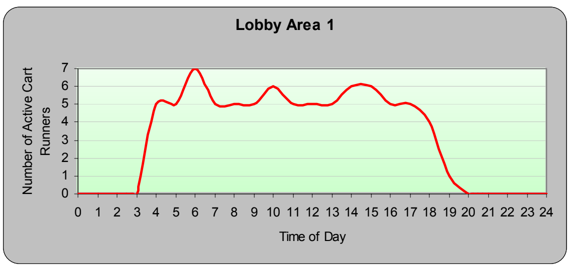

Figure 2: Number of Active Cart Runners

The requirements planning as shown above is then tallied across the different baggage screening areas of the airport to determine the overall equipment and staffing requirements for STL.

4 CONCLUSIONS

Simulation has been an excellent tool for determining the protocol and the number of machines required for baggage screening at STL. Different protocols with varying numbers of machines were tested and the "Drop-and-Go" option was chosen as the most viable one. Requirements for this protocol were determined using simulation and presented to TSA for approval. TSA approved the STL project team's plan and the approach was implemented.

5 FUTURE RESEARCH

After the required EDS/ETD machines are setup at the airport, the next big step is to deploy the security screening workforce. Staffing is not an easy task. The number of employees required for operating the EDS and ETD machines at the baggage screening areas is highly influenced by restrictions not observed in other systems. One of these restrictions is imposed by the need for rotating personnel that view the EDS screen. Another restriction is driven by training requirements. One more element to take into consideration is that demand may change along the day, and these variations may also be very different from one baggage screening area to the other baggage screening area. All these factors make staffing a very special component in the baggage screening planning process.

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