2.1. Ward, Passenger Wait Times for Screening at the Airport: Measuring, Modeling, and Analysis

1. **Modeling Area:** Risk Management  
2. **Principal Investigator:** Amy Ward  
3. **Institution:** USC  
4. **Other Investigators:** PhD Student Hailong Cui  
5. **Research Transition Lead:** Amy Ward

6. **Brief Description:**
TSA has a stated desire to decrease passenger wait times for airport screening. Even though substantial resources are devoted to passenger screening, passenger wait times can still be long. Pre-screening is one approach TSA has taken to decrease passenger wait times. However, as more passengers are pre-screened, the wait time for the pre-screened passengers have become longer. This is problematic, because TSA promises shorter wait times to pre-screened passengers.

We propose to develop a model that will show the effect of increasing the percentage of pre-screened passengers on both overall wait times (including both pre-screened and non-pre-screened passengers) and on pre-screened passenger wait times. As the percentage of pre-screened passengers increases, the overall wait times should drop, because the screening time for pre-screened passengers is shorter. Simultaneously, the wait time for pre-screened passengers should increase, because there are more pre-screened passengers arriving to the security checkpoint. Quantifying the effect of increasing the percentage of pre-screened passengers will allow more effective resource management, which, in turn, will ensure that pre-screened passenger wait times remain low.

7. **Objectives:**
The purpose of this project is to develop a model that shows the effect of increasing the percentage of pre-screened passengers on both overall passenger wait times and on pre-screened passenger wait times. The input to the model will be the passenger arrival process, the screening time distribution of pre-screened passengers, and the screening time distribution of non-pre-screened passengers. The output from the model will be predicted passenger wait times, as shown in the Figure 1 below. The important observation in the figure is that the wait time for pre-screened passengers has a “hockey-stick” curve; that is, past some percentage that wait time will increase exponentially fast. (See Section 11a for a brief explanation of how such a figure can be drawn.) The implication is that increasing the percentage of pre-screened passengers is extremely beneficial up until a certain point, at which time more resources must be deployed to keep pre-screened passenger wait times low.
Figure 1: Average wait time for all passengers and for pre-screened passengers as a function of the fraction pre-screened.

The curves shown in Figure 1 can be calibrated for any given airport based on data from that airport. The prototype model will be delivered via Excel.

8. Interfaces to other Center Projects
There is work by Adam Rose at CREATE that uses wait time measurements. We will ask Adam for help to understand what data he already has. In the process, we will see how our work can connect to his work on the economic impact of passenger waiting. His work in that context provides strong motivation for our project, which focuses on operational strategies (specifically, increasing the percentage of pre-screened passengers) to decrease average overall passenger wait time.

Note that this is the PI’s first time funded by CREATE, and so the PI is still understanding the best ways to interface with CREATE. Also note that the PI has already made effort in this direction by attending CREATE’s retreat earlier this year, and by separately meeting with Heather Rosoff for some advice on projects currently ongoing at CREATE.

9. Interfaces to non-Center Projects:
The PI is not aware of any interfaces to non-Center Projects, but is open to developing such connections.
10. Major Products and Customers:
The target audience is TSA. This ties in with TSA’s stated desire to use a risk-based pre-screening approach in order to decrease passenger wait times in airport security lines. Our goal is to work with TSA to quantify how much shorter we can make security lines if TSA is able to increase the number of passengers eligible for expedited screening to its stated goal of 50% by the end of 2014. We will also quantify what this means for the wait times of pre-screened passengers.

11. Technical Tasking.
   a. The Basic Model. The model we develop is based on queueing theory. To illustrate this approach, we consider a security checkpoint with one screening station. Suppose the screening time of a pre-screened passenger is $m_1$ minutes and $m_2 > m_1$ minutes for a passenger that has not been pre-screened. Then, if the percentage of arriving passengers that have been pre-screened is $f$, the average screening time is:

   $$ m = fm_2 + (1-f)m_1. $$

   The number of passengers a security guard can screen in one hour, on average, is

   $$ \mu = \frac{60}{m}. $$

   It follow from heavy-traffic queueing theory that if $\lambda$ is the overall passenger arrival rate and $\sigma^2$ is the variance that includes both variance in passenger arrival times and in screening times, then the overall wait time is approximated by

   $$ \sigma(f)^2 / 2[\lambda - \mu(f)], $$

   where we write $\sigma(f)$ and $\mu(f)$ to emphasize the dependence of these parameters on the fraction of pre-screened passengers. Equations based on this one were used to produce Figure 1. This approximation becomes extremely accurate when the system loading factor is high. Otherwise, the wait time prediction formula rely on Poisson process assumptions.

   b. Model Development. The first step is to understand the model features most desirable to TSA. In the process, we will ask for what shortcomings they see in the current screening process, and what improvements they are hoping for in the future. This will inform any improvements that we make to the basic model. We will begin by talking with William Burns and Richard John, who have done some work in this area. We will also talk with Erroll Southers. We would like to visit both the Burbank and Long Beach airports. We plan to spend a day at each watching the screening station, and interviewing the TSA employees.

   c. Model Calibration. The important metrics for this study are: passenger wait times and passenger screening times. We want to be able to collect this information in an automated fashion. We suspect that TSA already is doing this to some degree; for example, the baggage screening machine likely records timestamps. However, we are not sure that TSA records the time each passenger first arrives to the screening station and last departs. That information is necessary to understand the accuracy of the equations we will use to predict wait times based on the percentage of passengers pre-screened. Hence we would like to understand to what degree the assumption of Poisson arrivals and/or service times is valid. For that, we need passenger-by-passenger level data. We foresee using people counter technology to automate the arrival timestamp recording process. We must spend time investigating what is the appropriate people
counter technology to use. This is a big effort, and would have to be done with the support of TSA.

d. **(Possible) Data Collection.** Depending on what we learn in the model calibration phase, we may want to build a database that stores the screening-by-screening level data that gives each passenger’s arrival time to the security checkpoint, time his screening begins, time his screening takes, and his exit time from the security checkpoint. We envision that this database will be built partly from information already collected by TSA and partly from new information gathered using the people counters. We will investigate how to most easily automate the data collection process. The hope is that we would be allowed to do this at a small but busy airport like Burbank.

e. **Data Analysis and Recommendations.** We will quantify the reduction in overall average wait time, and the increase in prescreened passenger average wait time, as the percentage of pre-screened passengers increases. From data, supplied either by TSA or collected by us, we will see what current wait times are and how they vary based on time-of-the-day and day-of-the-week. We will use this to verify the predictive power of our model. That will allow us to have a better understanding of the impact of increasing the percentage of pre-screened passengers.

12. **Proposed Timeline and Deliverables.**


c. Show Excel tool to Erroll Southers, and gather his input on features of interest to TSA stakeholders. Months 2-4.

d. Put data collection mechanisms in place if needed and if given approval. Months 3-6.

e. As data becomes available, test model for predictive power and calibrate. Months 5-8.

f. Develop visual interface tools. Months 5-8.

g. Distribute prototype tool to users. Months 8-10.

h. Implement potential additional features that TSA stakeholders may want for the model. Months 10-12.