Anonymous Bluetooth Probes for Airport Security Line Service Time Measurement: The Indianapolis Pilot Deployment

by

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ABSTRACT

An anonymous Bluetooth tracking system was deployed at the new Indianapolis International Airport from May 8 to June 2, 2009 to measure the time spent waiting in security screening lines, transiting the security screening checkpoint and walking to Concourse B. The maximum security checkpoint queue was observed to be on Monday mornings at approximately 0600 when it could take passengers up to twenty minutes to transit the security queue, screening process and walk to Concourse B. Depending upon the day of the week, this approach was demonstrated to sample between 5% and 6.8% of the passengers. This modest sample size provides a much more robust measurement of screening times then the current system of manually passing out time stamped cards as passengers enter the queue and collecting them when they pass through the magnetometer. The paper concludes by suggesting this system could provide important information to managers to more effectively allocate scarce resources on both a local and national level as well as providing the traveling public with information they need in order to know how much time they should allocate for transiting the security screening process at an airport.

INTRODUCTION

Obtaining both historical and real-time measurement of the time that it takes passengers to transit through both the queue and security screening process at airport checkpoints is of interest to a variety of stakeholders. For example, passengers would benefit from this information by allowing them to schedule appropriate slack time in their arrival at the airport. Also, managers responsible for staffing security checkpoints at a specific airport would have quantitative information to schedule personnel necessary to respond to daily, seasonal, and special event/holiday traffic. On a national scale, quantitative data for security screening transit time for major airports across the country would allow government officials to be more agile in responding to changes in airport origin-destination traffic patterns. Additional intangible benefits would also accrue to the travelling public by managers using quantitative tools to systematically reduce security checkpoint delays that occur due to shifting travel patterns.

CURRENT MEASUREMENT TECHNIQUES

There are two primary techniques used for scheduling and assessing staffing resources at security checkpoints: checkpoint passenger counts and manual measurement of queue time. Figure 1 is an example of historical checkpoint passenger counts. This plot illustrates that most of the passengers pass through the security screening between 3am and 9pm, with the largest peak around 6am. These historical volumes can be augmented by airline reservation data to capture unusual demand patterns associated with holidays and large sporting events. However, these volumes only provide first order management tools because there are frequently differing demographics on different travel days and at different times. For example, there are differences in average passenger screening times between a business traveler and a family travelling on vacation. Screening times also vary due to factors such as amount of clothing worn by passengers in different region with different weather and temperature conditions.

Historically, this security volume data has been augmented by occasionally passing out time-stamped cards to passengers entering a security line queue and collecting them when they pass through the magnetometer. This technique is labor intensive for both the task of distributing/collecting the cards and the processing duties after they are collected. To obtain robust statistical estimates of average passenger transit, relatively large samples are necessary (1), but rarely collected for any substantive period. Consequently, there has been no development of planning level service time models that explicitly consider important factors such as passenger volume, regional characteristics, checkpoint layouts, and/or weather to model modern security checkpoints.

It would be desirable to implement real-time security transit time so that wait times could be directly measured for management and customer relations. The longer term benefit of deploying such systems would be a rich data set to develop accurate queuing models, such as have been developed for other transportation areas such as highway operations(2).

MEASUREMENT TECHNOLOGIES

There are a variety of technologies that can be used for real-time measurement of transit time in transportation systems, but in general they all fall into the category of matching unique identifiers between two points. For example, one of the oldest methods for estimating transit time between two points is to use two observers stationed at two different points along a route with each writing down license plates and the time that a vehicle pass a point on the highway (Figure 2a) (3, 4). After the data recording is completed and observers return to the office, the license plates are "matched" and the difference in observation times is recorded. This basic technique was first developed in the 1940's, but has been enhanced over the years to include the use of computer image processing to automatically capture the license plate or other unique identifiers such as electronic ID numbers associated with toll tags or electromagnetic characteristics of vehicles.

Recently, agencies have extended these this technique further and begun using roadside devices to capture the discoverable unique 48 bit MAC addresses associated with discoverable Bluetooth devices in the vehicles such as cell phones (Figure 2b), GPS devices, mp3 players, hearing aids, and hands free devices (5). Not all vehicles have discoverable Bluetooth devices, but in general it has been reported that 5%-12% of the vehicles have one or more such discoverable devices on board (6). This sample size is large enough to develop very accurate estimates of segment travel time. Figure 3 illustrates the type of travel time information that is typically collected by highway agencies to identify periods of the day were long queues are developing and establishing proactive work zone management strategies and public communication procedures. The travel time plot shown in Figure 3 shows travel time measured over a 20 mile period in the Southbound direction of I-65 in Northwest Indiana. The increased traffic volume on Friday and Sunday show that the travel time over that 20 mile segment increases by over 1 hour during those periods. On Monday's, the travel time through the construction zone increases by approximately 40 minutes during the afternoon period.

INDIANAPOLIS AIRPORT CASE STUDY

In an airport environment, the travel time measurement problem is essentially the same as highways, except it is the transit time of pedestrians (not vehicles) that is of interest and the distances are typically much shorter. Figure 4 illustrates the location of two reference points that can be used for measuring the transit time through a security queue, security screening, and pedestrian path to the sterile Concourse B area at Indianapolis International Airport.

In this study, equipment similar to that used for roadside vehicle detection was placed at the locations shown in Figure 5 and Figure 6. However, this study used lower powered Class II Bluetooth radio receivers that had an approximate range of 10 meters as opposed to 100 meters (Table 1). Figure 7 illustrates how these two monitoring locations can be used to capture the unique identifier “00:21:06:8C:7A” of an anonymous cell phone (Figure 2b) as the passenger carrying the cell phone enters the security line at 08:49, waits in the security screening line, is screened, and then enters Concourse B at 08:59.

Figure 8 illustrates how the duration of this passenger transit time can be plotted throughout the day to characterize security line wait times. Of particular note is the contrast in the pattern of travel time shown in Figure 3 vs. the pattern of travel times shown in Figure 8. In the Interstate Highway example, most of the motorists join a single queue, except for a few that divert at exits and travel on adjacent local roads. However, in an airport, there are several “routes” through the security checkpoint. In the case of Concourse B at Indianapolis Airport at the time of the study, there were separate lines for

- Expert travelers
- Families
- The commercial service “Clear” (which has since ceased operation at IND)
- Airline crews

Furthermore, additional “noise” in the passenger security transit time plots for airports occurs because not all passengers take a direct, linear path through security to their gate. Therefore, there are some outlier travel times that are not representative of transit time through the security screening checkpoint. For example, from the pattern of travel times plotted in Figure 8 it obvious that the security line transit times larger than 20 minutes after 0900 are not representative of a passenger that proceeds directly through the security screening area to Concourse B.

As a result, the travel times shown in Figure 8 require some judgment in interpreting typical transit times. However, it is fairly clear that the security transit time peaks around 0600 at about 20 minutes, and then tapers off to a maximum time of 10-15 minutes throughout the rest of the day. The actual time waiting in the security line is considerably less because the plot shown in Figure 8 includes the time required for passengers to pass through security, reassemble their belongings, put their shoes on, and walk approximately 200 feet to pass the sensor on Concourse B (Figure 4).

Although daily security travel time plots like the one shown in Figure 8 are helpful, examining them in the context of passenger volumes can provide additional insight. Figure 9 shows the passenger volumes for Concourse B security screening during the period this pilot study was conducted and Figure 10 shows the corresponding travel time plots over the same period. A couple of trends are apparent when examining both of these plots:

- Figure 10 shows the peak security transit time is approximately 20 minutes and occurs on Monday May 11 during the morning peak. Figure 11 shows a detailed hourly comparison between the passenger count and the security transit time on May 11 with obvious correlation between the passenger count and security travel time.
- There are approximately 30% more passengers departing on Monday May 25 (Memorial Day), but the typical security transit time is less than 15 minutes throughout the day.

Using the passenger counts and the number of uniquely matched Bluetooth MAC addresses, Figure 12 shows that between 5% and 6.8% of the passengers have discoverable Bluetooth devices on any given day. This is slightly lower than observed in a typical freeway traffic stream, but still large enough to very accurately characterize the transit time through an airport security checkpoint.

PRIVACY ISSUES

The MAC address shown in this research was for one of the paper co-authors. In a full deployment, consideration needs to be given to designing the data collection and destruction procedures. For example, the Indiana Department of Transportation has recorded over 1.4 million travel times for the construction work zone shown in Figure 3, but has based all of their travel time calculations on MAC address that have had 3 digits (octets) deleted. This is analogous to not recording some of the digits on a vehicle license plate. When such a clipping procedure is implemented at the data collection point, there is sufficient uniqueness in the data set to obtain very reliable travel time estimates, but not enough information to be able to prove the presence of a device with a specific MAC address at a particular time. More complex hashing algorithms could also be developed.

Furthermore, once a match has been made between the two checkpoints shown in Figure 4, there is no need for an airport to maintain the MAC address and it can be discarded after a few hours.

CONCLUSION AND FUTURE RESEARCH

This paper demonstrated that technology currently used to measure travel time along freeways and signalized arterials can be easily adapted to an airport environment to measure the transit time through a security checkpoint. The only technical modification was that Class II (instead of Class I) receivers were used to reduce the sampling radii of the Bluetooth monitoring devices. In comparison to highway environments, the 5-6.8% of passengers with discoverable Bluetooth devices on their persons was slightly lower, but large enough to accurately characterized passenger transit time through security.

This technology is currently deployed in highway environments for less than $5000 per installation. With the potential to collect continuous security time transit time data, this has the potential to provide managers with information to most effectively allocate scarce screening resources at both the local airport level and national level.

This pilot study was conducted at the new Indianapolis Airport Terminal that was opened in November 2008 with highly structured security checkpoints. This technology could be readily deployed at other airports throughout the country as well, but might require site specific use of directional antennas to accommodate nuances of older airport terminals.

Lastly, long term collection of i) passenger counts, ii) security transit times, and iii) security checkpoint configurations, and iv) security checkpoint staffing levels would allow the development of higher fidelity quantitative models relating passenger counts with security transit times (Figure 11).

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REFERENCES

1. Quiroga, C. and D. Bullock, “Determination of Sample Sizes for Travel Time Studies,” Institute of Transportation Engineers Journal on the Web, Volume 68, Number 8, pp. 92-98, August 1998.
2. “Highway Capacity Manual 2000,” Transportation Research Board, National Research Council Washington, D.C., 2000.
3. Schaefer, M.C., “License Plate Matching Surveys: Practical Issues and Statistical Considerations,” Institute of Transportation Engineers Journal, Volume 58, Number 7, July 1988.
4. Robertson, H., J. Hummer, and D. Nelson, "ITE Manual of Transportation Engineering Studies", Prentice Hall, 1994.
5. Wasson, J.S., J.R. Sturdevant, D.M. Bullock, “Real-Time Travel Time Estimates Using MAC Address Matching,” *Institute of Transportation Engineers Journal*, ITE, Vol. 78, No. 6, pp. 20-23, June 2008.
6. Brennan, T.M., J.M. Ernst, C.M. Day, D.M. Bullock, J.V. Krogmeier, and M. Martchouk, “Influence of Vertical Sensor Placement on Data Collection Efficiency from Bluetooth MAC Address Collection, submitted to ASCE Journal of Transportation Engineering, May 2009.

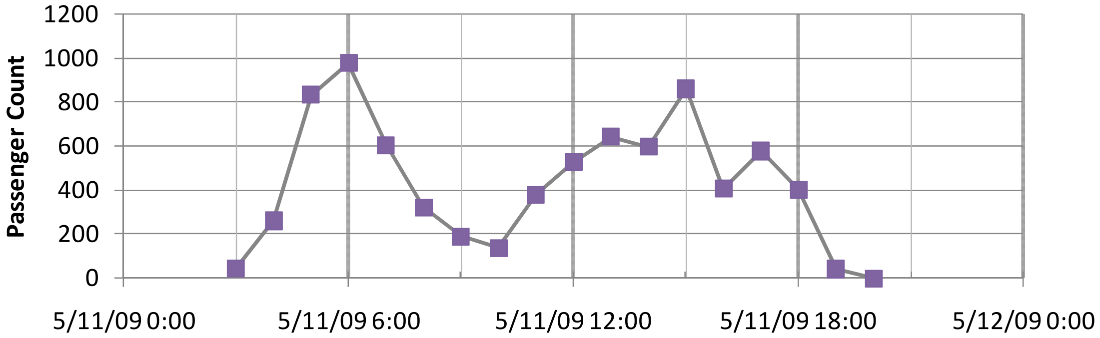


Figure 1: Concourse B passenger volume for May 11, 2009.

Bluetooth Options
Device Name: BlackBerry 8310
Discoverable: Yes
Allow Outgoing Calls: Always
Address Book Transfer:
All Entries
LED Connection Indicator: On
Device Address:
00:21:06:8C:18:7A
Services:
Headset

a) Visible plate number

b) Electronically visible device address

Figure 2: Examples of unique identifiers that can be recorded to measure segment transit time.

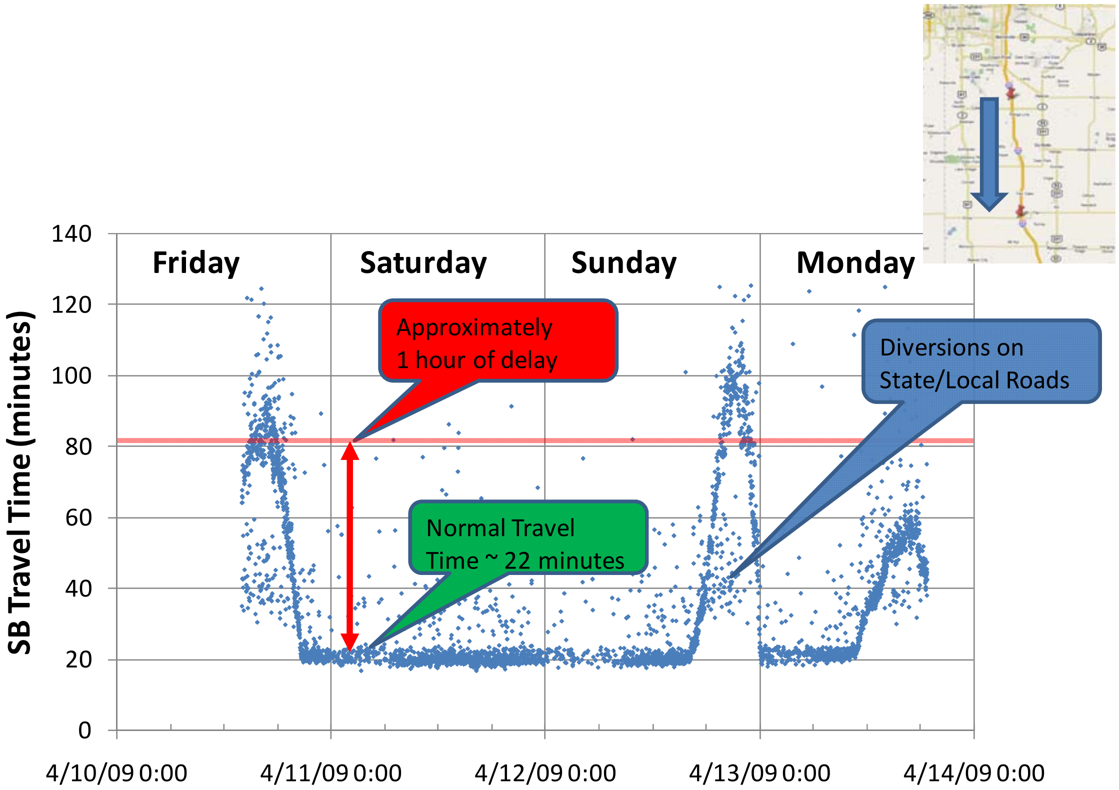
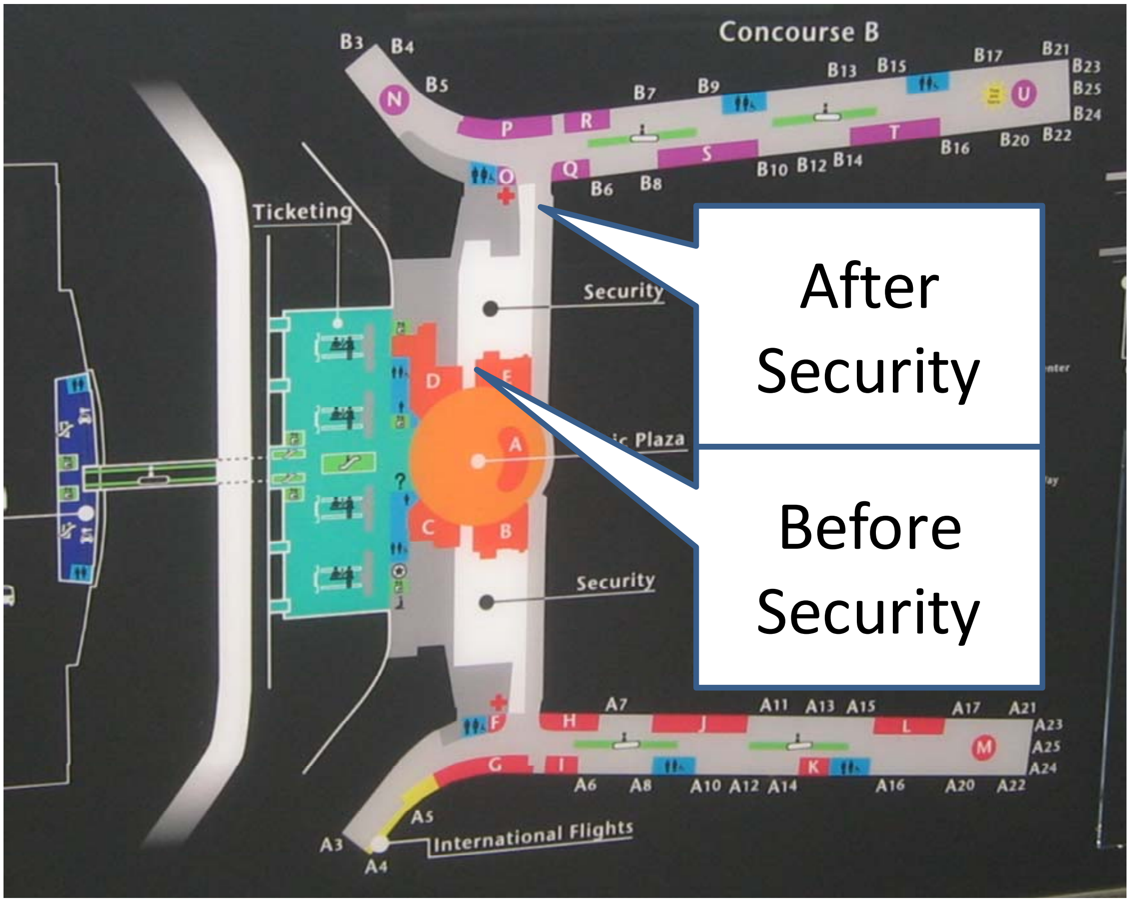


Figure 3: Example travel time through an Interstate Highway construction zone with significant queuing.



After Security

Before Security

Figure 4: Reference points for measuring transit time through Concourse B security screening.

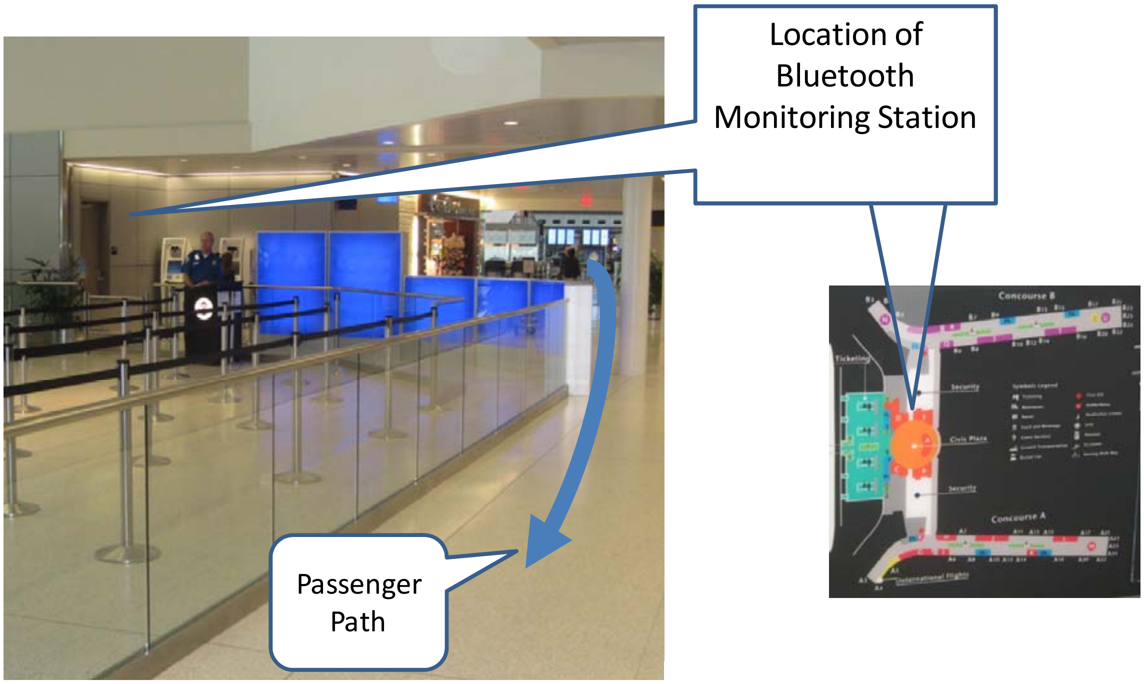


Figure 5: Location of Bluetooth monitoring station prior to passengers entering Concourse B security line.

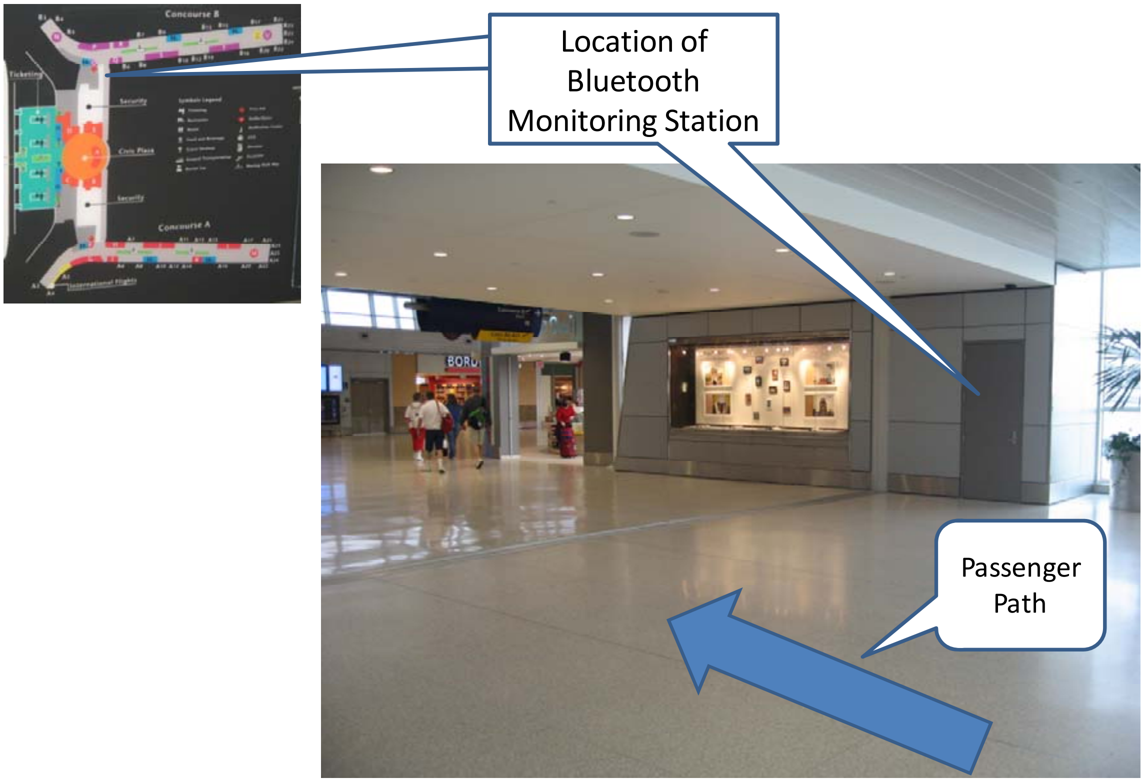


Figure 6: Location of Bluetooth monitoring station after passengers clear Concourse B security screening.

Passenger departing security screening area with discoverable Bluetooth address 00:21:06:8C:7A observed at 08:59

Passenger entering security line with discoverable Bluetooth address 00:21:06:8C:7A observed at 08:49

Figure 7: Example measurement of a 10 minute transit from the entrance to Concourse B security screening area at 8:49 to the secure area of Concourse B at 8:59.

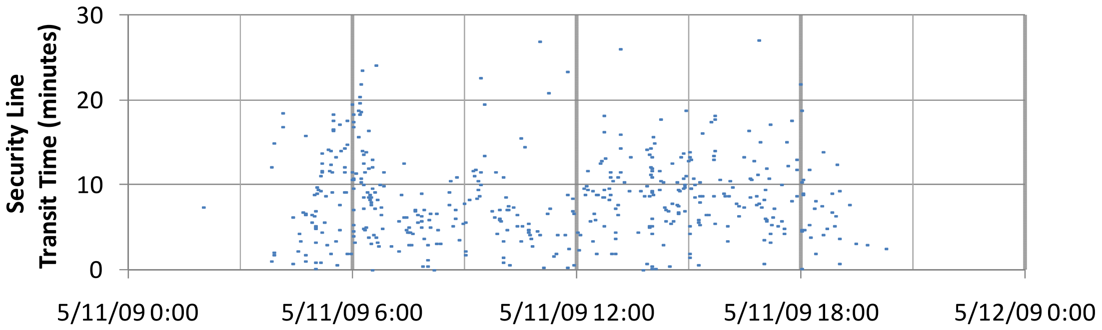


Figure 8: Concourse B Security Line Transit Time for May 11, 2009..

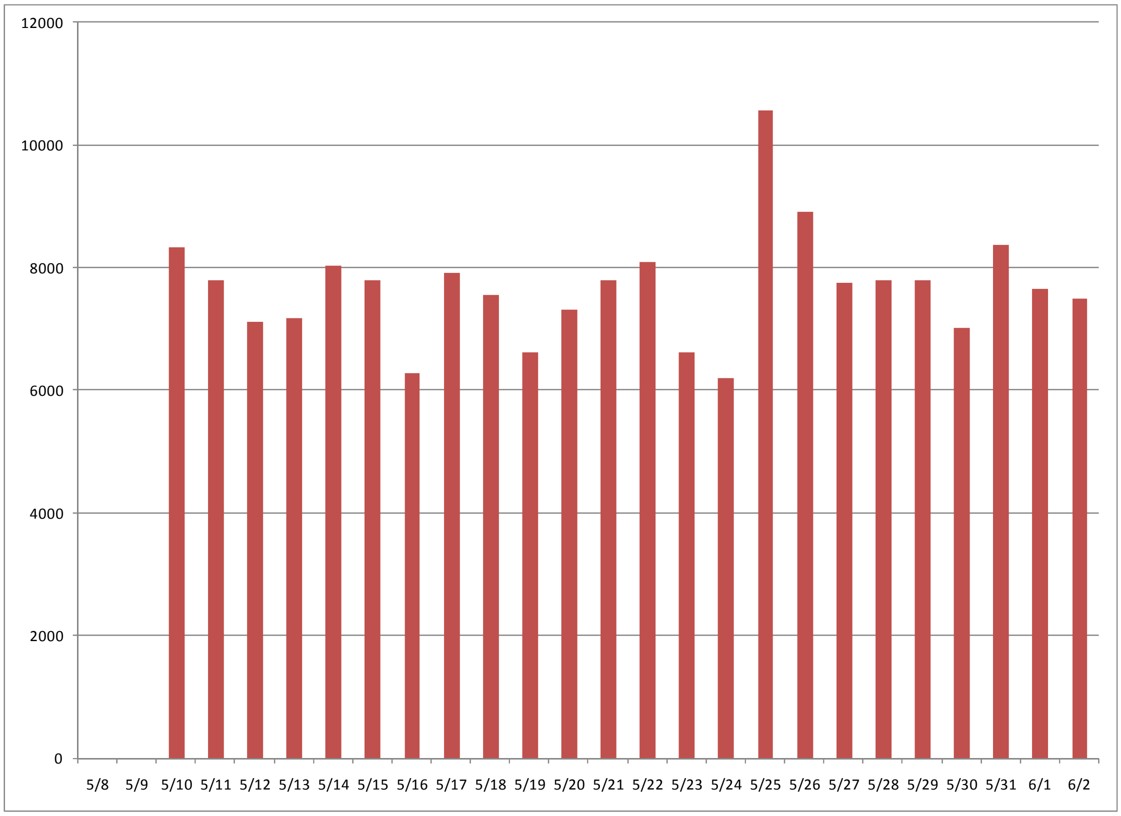


Figure 9: Concourse B Passenger volume from May 10 through June 2, 2009.

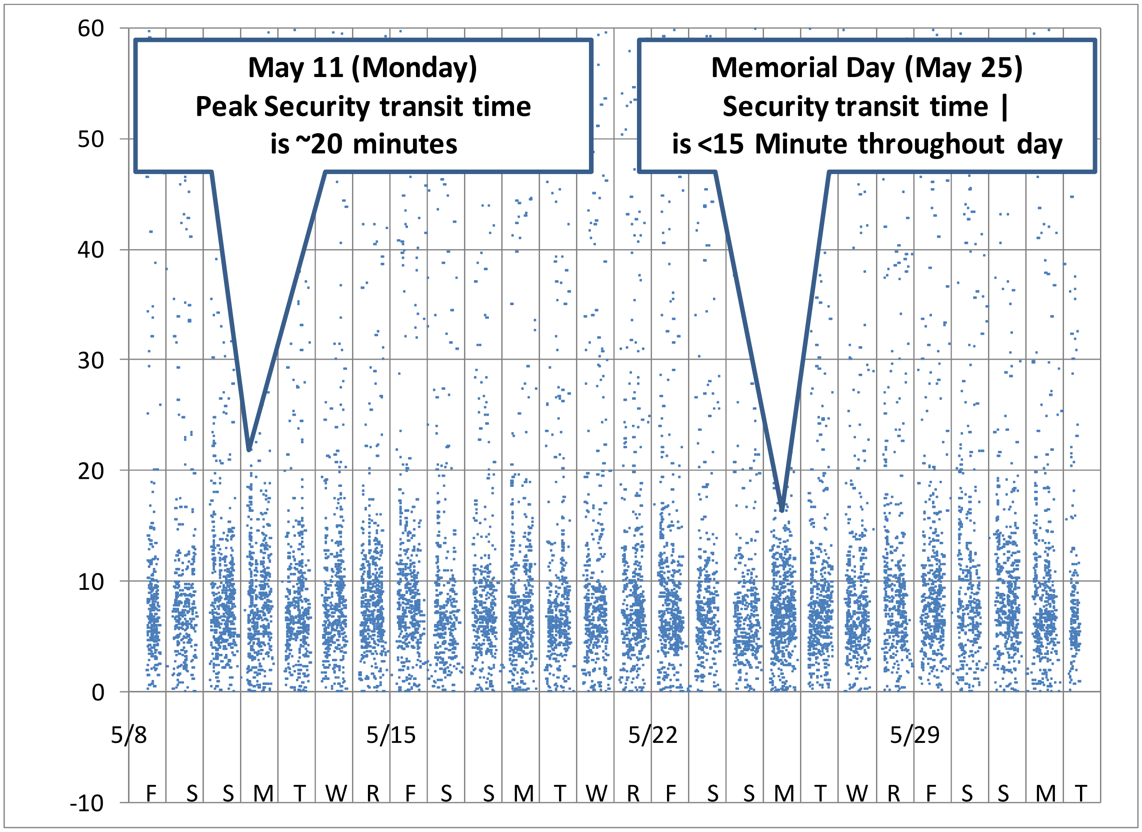


Figure 10: Passengers transit time from the entrance to Concourse B security screening area to the secure area of Concourse B during period May 8 through June 2, 2009.

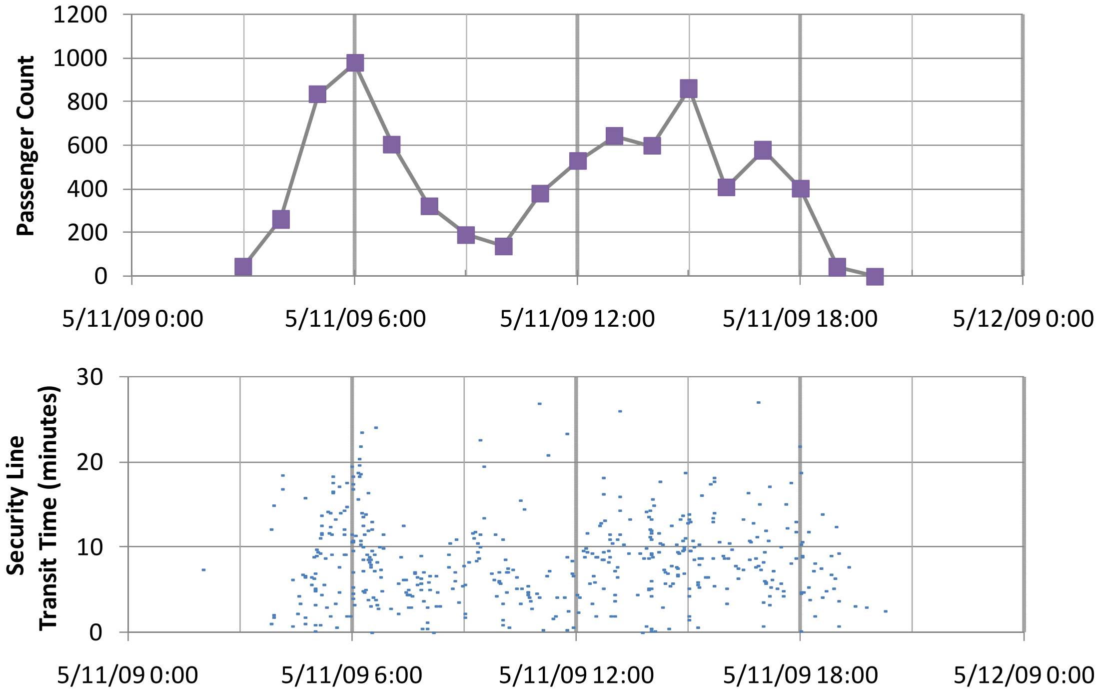


Figure 11: Comparison of Concourse B Security Line Transit Time and Passenger Count for May 11, 2009.

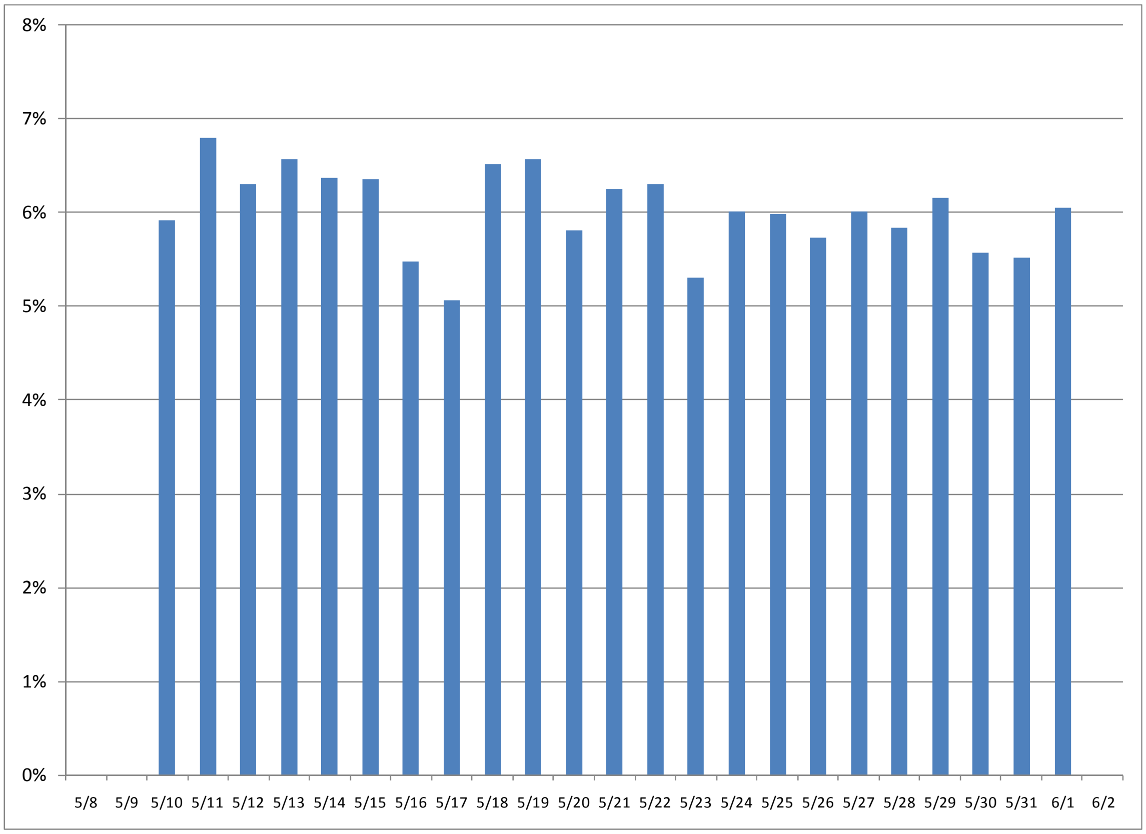


Figure 12: Percentage of Concourse B Passenger volume per day of passengers with discoverable Bluetooth devices matched between Bluetooth monitoring station from May 10 through June 1, 2009.

Table 1: Categories of Bluetooth device power and approximate range.

Class	Maximum Power	Typical Operating Range
Class 1	100mW (20dBm)	~100 meters
Class 2	2.5mW (4dBm)	~10 meters
Class 3	1mW (0dBm)	~1 meter