APPENDIX B
AIRPORT SECURITY SPACE PLANNING

Section A - Introduction

This Appendix provides general methodology, equations and information used to determine the approximate number, size and configuration of space required for security screening checkpoints. These are generic formulas based on time-tested airport industry security flow modeling experience. While they will not necessarily provide a final design solution, they are an excellent tool for determining the space planning requirements in the initial planning phases of new or modified construction. Refer to the Security Screening section on page 87 for further information.

Section B - Space Planning Aids

This section presents calculations used to determine the number, size and configuration of required SSCP's.

- Growth factors for anticipated future increases in traffic and the accompanying increases in expanded terminal space should also be considered by the planner, bearing in mind that there are typically several years lag time between conceptual terminal design and actual construction, and that FAA estimates between 3%-5% annual passenger growth.
- The planner’s calculations must also adjust estimates of peak hour volumes for situations where split operations, multiterminal operations and multiple SSCP may serve to distribute peaks, either evenly or unevenly, throughout various terminals and/or concourses.
- Similar calculations and formulas are used by International Air Transport Association (IATA) and planners in the United Kingdom’s Department of Transport document “Aviation Security in Airport Development”.

1. Planning Passenger Volume

Airports experience very large variations in demand levels over time which can be described in terms of:

- Annual variation over time
- Monthly peaks within a particular year
- Daily peaks within a particular month or week
- Hourly peaks within a particular day

Many airport terminals are busy for various time segments in a day, and have no traffic for some other periods during the day. In order to determine the number of SSCP's, annual or daily demand does not provide sufficient information. There is a need to capture the levels of demand on the SSCP's for the peak periods during the planning day. However, the choice of the planning day is important. It is not advisable to select the planning day as the busiest day of the entire year since that will oversize the facility, resulting in underutilization and high design and building costs.

One commonly used technique is to identify a peak hour for which the facility is to be designed and compute the total passenger volume for that period. The peak hour volumes typically range from 10% to 20% of the daily volume. There are several methods to determine the design load on the SSCP's, and the list below identifies four methods:

a. Typical Peak Hour Passengers (TPHP)
b. Busy Day/ Peak Hour (BDPH)
c. Standard Busy Rate (SBR)
d. Busy Hour Rate (BHR)

a. Typical Peak Hour Passengers (TPHP)

The planning day is suggested to be the Average Day of the Peak Month (ADPM). ADPM represents the most common method of converting planning statistics to a daily and ultimately to an hourly demand baseline. The determination of ADPM requires the identification of the peak month for the facility under consideration. Most common peak months are July and August. The next step is to identify an average day demand profile for the peak month. This is typically calculated by dividing the peak month demand by the number of days in the peak month.

The Typical Peak Hour Passengers denote the number of passengers for the peak hour of the planning day (ADPM). The peak hour in a planning day can be calculated based on the actual flight schedule for the ADPM. Typically, large airports have peak hour volume of 10 to 20 percent of the daily volume. As seen in this figure, the peak is more pronounced for smaller airports, and as airports grow larger, the peaks flatten since there are departures and arrivals scheduled throughout the day. For SSCP design purposes, only the annual departures (enplanements) should be considered in the peak hour volume. If the annual volume includes both arriving and departing passengers, one can assume that half of the total volume accounts for the departing passengers. Greeters, family, etc., are accommodated in the formulas.

![TPHP as a Percentage of Annual Flows](image)

**Appendix B Figure B-1 - Recommended Relationship for TPHP Computations from Annual Figures**

b. Busy Day/Peak Hour (BDPH)

IATA suggests the BDPH method for design and planning purposes. The “busy” day is defined as the second busiest day in an average week during a peak month. An average weekly pattern of passenger traffic is calculated for that month. Peaks associated with special times such as national holidays, festivals, fairs, special events are excluded. The busy day data can be obtained from the airport tower log. Once the aircraft movements are obtained, passenger volumes can be plotted by time-of-day with appropriate load factor assumptions. This will lead to the selection of peak hour and corresponding passenger volume within that 60-minute period. The detailed security checkpoint planning will then be based upon the busy hour passenger volume.

Take care that calculations are not skewed by airline scheduling anomalies, such as the common practice of multiple airlines scheduling their first flight of the day at 6:59 a.m. or 7:59 a.m. in order to be the first one listed in the reservations computers.

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c. Standard Busy Rate (SBR)

The Standard Busy Rate measure is mostly used in Europe. It is defined as the anticipated level of demand during a busy hour. For example, some European airports use 30th busiest hour of passenger flow for the entire year. SBR demand in practice is very similar to that of TPHP. The IATA recommends that the extraordinarily high-traffic seen for major holidays be excluded in selecting busy periods.


d. Busy Hour Rate (BHR)

The BHR is a variation of the SBR where the volume is estimated by the rate above which 5 percent of the traffic at the airport is handled. It is computed by ranking the hourly operational volumes for the entire year, and then selecting the hourly volume for which 5% of all hourly volumes is exceeded.

There are other lesser-used techniques utilized to compute the peak volume; namely Busiest Timetable Hour, Peak Profile Hour, and several other variations.

2. Calculations

The calculations presented in this section should be used as a general guideline to determine the number of SSCPs. In order to estimate the number of required SSCPs, the following parameters need to be defined first.

a. Demand Parameters

\[ P = \text{Planning hour passenger enplanement volume. (People per hour)} \]

\[ T = \text{Percentage of transfer passengers that bypass screening. E.g., 0.2 represents 20\% of passengers connecting within the secured area, who thus need not go through screening.} \]

\[ K = \text{A percentage of originating passengers to represent meeters/greeters, well-wishers, employees, and vendors using the SSSPs.} \]

\[ r = \text{Demand scale factor between 1 and 1.4 to account for variability of arrival rate through the planning hour.} \]

\[ L = \text{Effective demand on the SSCP. (Includes passengers, meeters/greeters, well-wishers, and airport employees.)} \]

b. SSCP Parameters

\[ S = \text{Service rate of the SSCP. (People per hour)} \]

\[ f = \text{SSCP utilization factor. Typically between 0.80 and 0.95. This multiplier represents the utilization factor for both the equipment and staff. It is essential in the design that the equipment and staff is not designed to operate on full capacity. This factor accounts for equipment breakdowns, staffing fluctuations, and other disruptions in the process.} \]

\[ X = \text{X-ray belt service rate. (Bags per hour)} \]

\[ B = \text{Number of carry-on bags per passenger.} \]

The effective hourly load on the SSSPs is a function of the peak hour enplanements, the transfer percentages within the secured area, other traffic such as the meeters/greeters, well wishers, employees and vendors represented as a percentage of enplanements, as well as the demand scale factor \( r \).

\[ L = P \times (1 - T) \times (1 + k) \times r \]

Equation 1

The demand scale factor \( r \) plays an important role in determining the “true” peak load on the SSSPs.

Consider the following example. Assume a peak flow of \( P = 1,600 \) enplaning passengers per hour, with \( T = 25\% \) of passengers transferring within the secured area and other traffic (meeters/greeters, well wishers,
employees and vendors) accounting for $k=15\%$ of enplaning passengers. With a demand scale factor of $r=1$, the effective hourly load on the SSCP is:

$$L = 1,600 \times (1 - 0.25) \times (1 + 0.15) \times 1.0 = 1,600 \times 0.75 \times 1.15 \times 1.0 = 1,380$$

In this example, $L=1,380$ indicates a constant arrival pattern where people arrive to the SSCP with $1,380/60=23$ people per minute. However, this will not be the case in many airports. The figure below shows three different arrival patterns, all of which have the same arrival rate of 1,380 passengers per hour.

**Appendix B Figure B-2 - Different Arrival Rates to SSCPs - All Cases with 1,380 passengers per hour**

**Case A** assumes a constant arrival pattern where arriving passengers are spread uniformly. This results in a constant demand on the SSCPs with 23 passengers per minute.

**Case B** is more realistic by assuming random arrivals where the per minute rate changes between 10 to 40 passengers per minute, with the same total of 1,380 passengers arriving in an hour.

**Case C** also has variation in the number of passengers arriving per minute, but also with a total of 1,380 passengers arriving in an hour. However, in this case, the arrivals peak in the middle of the peak hour.

c. The Effect of Demand Scale Factor $r$

The demand scale factor $r$ is used to represent the effective demand on the SSCPs. This quantity typically ranges from 1.0 to 1.5 depending on the variation in the arrival process.

**Case A - Constant Arrival – No Variation**

In this case, the demand scale factor $r$ can be set to 1.0. Case A in the Figure represents this. This case is not very realistic since passengers do not arrive at the SSCP in a constant flow or pattern.

**Case B - Typical Arrival – Medium Variation**

This case represents medium variation in the demand, and is seen in main SSCPs used by originating passengers in medium-scale airports. In this scenario, the arrival rate is metered by the ticketing operation. This case presents more load on the SSCPs due to randomness in the arrival pattern, thus warrants the use of larger $r$, possibly between 1.0 to 1.2. Case B in the Figure represents this.
Case C - Busy Hub – High Variation

This is a typical arrival patterns for hub operations during busy bank departures. This case warrants for the use of large $r$, possibly between 1.1 and 1.4. Case C in the Figure represents this. The choice of large $r$ is also warranted for large transfer operations that require security processing.

3. Number of Checkpoints – Centralized (General Configuration)

This section presents general formulas and calculations for determining the number of checkpoints for a centralized SSCP.

a. Required parameters

$P$ = Peak hour enplanements
$T$ = Transfer percentage
$k$ = Percentage of enplaning passengers to account for other airport traffic
$r$ = Demand scale factor between 1 and 1.5
$f$ = SSCP utilization factor
$S$ = SSCP service rate in people per hour

b. Number of Checkpoints

The formula shown below can be used to determine the required number of checkpoint stations:

$$N_{\text{checkpoints}} = \frac{P \times (1 - T) \times (1 + k) \times r}{S \times f}$$

Equation 2

c. Example

$P$ = 1,600 passenger per peak hour.
$T$ = 25% of passengers transferring within the secured area.
$k$ = 15% of enplaning passengers to account for other traffic (meeters/greeter, well wishers, employees and vendors.)
$r$ = Demand scale factor of 1.2 to account for randomness in arrival pattern.
$f$ = 80%
$S$ = 600 people per hour.

$$N_{\text{checkpoints}}(r=1.2) = \frac{1380 \times 1.2}{600 \times 0.8} = 3.45 = 4$$

In this example, the demand scale factor of $r=1.2$ dictates 4 screening stations. To facilitate the discussion on the effect of $r$, let’s assume that the facility serves a uniform demand, thus $r=1$. Under this scenario, the total number of required screening checkpoints is calculated as:

$$N_{\text{checkpoints}}(r=1) = \frac{1380 \times 1.0}{600 \times 0.8} = 2.875 = 3$$

This example shows the importance of demand pattern throughout the peak hour. If arrivals throughout the peak hour can be assumed to follow a uniform pattern, than $r$ should be set to 1. However, arrivals follow a bell-curve shape throughout the peak hour, thus setting $r$ to 1.2 is more realistic.

4. Number of Checkpoints – Centralized (X-Ray + Metal Detector)

In this common SSCP setup, a combination of x-ray belt and metal detector is used to check baggage and passenger, respectively.
a. Required parameters

\[
P = \text{Peak hour enplanements} \\
T = \text{Transfer percentage} \\
k = \text{Percentage of enplaning passengers to account for other airport traffic} \\
r = \text{Demand scale factor between 1 and 1.5} \\
f = \text{SSCP utilization factor} \\
X = \text{X-ray belt service rate in bags per hour} \\
B = \text{Number of carry on bags per passenger} \]

b. Number of Checkpoints

The required number of x-ray processing stations is:

\[
N_{x-ray} = \frac{P \times (1 - T) \times (1 + k) \times r \times B}{X \times f}
\]

c. Example

\[
P = 1,200 \text{ passengers per hour} \\
T = 50\% \text{ of passengers transferring within the secured area} \\
k = 15\% \text{ of enplaning passengers to account for other traffic (meeters/greeter, well wishers, employees and vendors.)} \\
r = \text{Demand scale factor of 1.2} \\
f = \text{SSCP utilization factor of 0.9} \\
X = 700 \text{ bags per hour} \\
B = \text{An average of 1.5 bags per passenger} \\
\]

\[
N_{x-ray} = \frac{1,200 \times (1 - 0.50) \times (1 + 0.15) \times 1.5 \times 1.2}{700 \times 0.9} = 1.97 = 2
\]

This formula results in 2 x-ray devices, which could be served by a common metal detector, and a secondary manual search station staffed accordingly.

5. Number of Checkpoints – Holdroom (X-Ray + Metal Detector)

This section presents security checkpoint sizing formulas where SSCP are placed at the entrance of the holdroom. In this scenario, the terminal concourse is not secured, and passengers clear security only at the gate holdroom. It is assumed that a combination of x-ray belt and metal detector is used to check baggage and passenger, respectively.

a. Required parameters

\[
M = \text{Maximum number of passengers on a departing flight handled at the gate holdroom.} \\
T = \text{Transfer/through percentage} \\
k = \text{Percentage of enplaning passengers to account for other airport traffic} \\
r = \text{Demand scale factor between 1 and 1.5} \\
f = \text{SSCP utilization factor} \\
X = \text{X-ray belt service rate in bags per hour} \\
\]
b. Number of Checkpoints

The required number of x-ray processing stations is:

\[
N_{x-ray} = \frac{M \times (1 - T) \times (1 + k) \times r \times B}{X \times f \times (G / 60)}
\]

c. Example

\[
\begin{align*}
M & = 340 \text{ passengers} \\
T & = 10\% \text{ (The percentage of through passengers that remain on board)} \\
k & = 0\% \text{ (Only passengers holding boarding ticket/cards are allowed in the holdroom)} \\
r & = \text{Demand scale factor of 1.2} \\
f & = \text{SSCP utilization factor of 0.9} \\
X & = 800 \text{ bags per hour} \\
B & = \text{An average of 1.5 bags per passenger} \\
G & = \text{The gate is open for 50 minutes prior to the departure}
\end{align*}
\]

\[
N_{x-ray} = \frac{340 \times (1 - 0.10) \times (1 + 0) \times 1.5 \times 1.2}{800 \times 0.9 \times (50 / 60)} = 0.918 = 1
\]

The formula results in 1 x-ray device, which can be served by a metal detector and a secondary manual search station.

When the holdroom serves more than one gate with simultaneous departures, the parameter M needs to be adjusted to represent the sum of all passengers leaving the holdroom in an hour.

6. Queue Size

The space needed for queuing in front of the SSCP and the amount of time passengers wait to be processed are both dependent upon the SSCP processing rates. The higher the processing capacity, the queues and wait times will be shorter. In designing the space around the SSCP, one often targets a maximum waiting time tolerable by individuals. This time is typically in the magnitude of 2 to 8 minutes. There is a theoretical queuing rule known as Little’s Result that shows that the average number waiting in the queue is a product of the arrival rate and the average waiting time in the queue. Using this result, the equation below gives the necessary queue size.

a. Required parameters

\[
\begin{align*}
P & = \text{Peak hour enplanements} \\
T & = \text{Transfer percentage} \\
k & = \text{Percentage of enplaning passengers to account for other airport traffic} \\
W_{target} & = \text{The target maximum wait time in the queue. Typically between 2 to 8 minutes.} \\
r & = \text{Demand scale factor between 1 and 1.5}
\end{align*}
\]

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The effective demand on the SSCP is denoted by $L$ and is described below.

$$L_{\text{minutes}} = \frac{P \cdot (1 - T) \cdot (1 + k) \cdot r}{60}$$

The number of people waiting to be serviced by the SSCPs can be expressed as:

$$Q_N = L_{\text{minutes}} \cdot W_{\text{target}}$$

b. Example

Let’s consider the example provided earlier that required 2 x-ray processors:

- $P = 1,200$ passengers per hour
- $T = 50\%$ of passengers transferring within the secured area
- $k = 15\%$ of enplaning passengers to account for other traffic (meeters/greeter, well wishers, employees and vendors.)
- $r$ Demand scale factor of 1.2
- $W_{\text{target}}$ Tolerable wait time of 5 minutes

The effective demand per minute is given by $L$:

$$L_{\text{minutes}} = \frac{1,200 \cdot (1 - 0.5) \cdot (1 + 0.15) \cdot 1.2}{60} = 13.8$$

With target maximum waiting time of $W_{\text{target}}=5$, the number of people expected to queue in front of the SSCP is given by $Q_N$:

$$Q_N = 13.8 \cdot 5 = 69$$

With two x-ray machines, there will be two queues each with approximately 35 passengers.