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# Checkpoint Effectiveness and Efficiency Evaluation

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J. L. Fobes, Ph.D.
Michael D. Snyder
Brenda A. Klock

Aviation Security Research and Development Division
William J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

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Final Report



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16. Abstract:

This document describes a method to measure the operational effectiveness and efficiency of airport security checkpoints. Evaluating these two factors begins with determining their Critical Operational Issues and Criteria as well as the accompanying Measures of Performance. Checklists are included for acquiring the basic information through observation of the checkpoint (directly or with video cameras) and Threat Image Projection data.


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## ACRONYMS

| | |
|---|---|
| COIC | Critical Operational Issues and Criteria |
| ETD | Explosive Trace Detection |
| FAA | Federal Aviation Administration |
| MOP | Measure of Performance |
| $P_d$ | Probability of Detection |
| $P_{fa}$ | Probability of False Alarm |
| TIP | Threat Image Projection |

## 1. INTRODUCTION.

The Aviation Security Improvement Act, Public Law 101-604, mandates the Federal Aviation Administration (FAA) to enhance and improve security checkpoint operations. The Aviation Security Human Factors Program (AAR-510), of the Aviation Security Research and Development Division, is the FAA unit tasked with this responsibility.

### 1.1 Overview.

Checkpoint operations can be subdivided into a set of discreet tasks performed by screeners and their supervisors. Each task serves the overall mission of effectively (deterring and detecting threats) and efficiently (minimum effects on throughput) processing passengers and their carry-on baggage. Evaluating these two factors begins with determining the Critical Operational Issues and Criteria (COIC) for checkpoint effectiveness and efficiency. Measures of Performance (MOP) are then identified to guide information gathering as needed to evaluate the issues in terms of whether or not criteria are met. Checklists are then developed to acquire the information for the MOPs through observation of the checkpoint (direct or with video cameras) and Threat Image Projection (TIP) data. This evaluation process is based on a foundation of checkpoint tasks and their underlying Knowledge, Skills, and Abilities [1].

### 1.2 Scope.

This document describes a process to collect, analyze, and evaluate data on the effectiveness and/or efficiency of the airport security checkpoint. Potential applications include attempts to improve effectiveness or efficiency wherein a checkpoint baseline performance is determined, some intervention(s) is attempted to improve security, and post-intervention measures are gathered and compared to the baseline to determine the consequence of the intervention. Another potential application is estimating compliance with security requirements by the FAA, airlines, guard companies, or airports.

## 2. CRITICAL OPERATIONAL ISSUES AND CRITERIA.

Interpreting the COIC may be affected by the amount of activity at the checkpoint as well as the amount of security personnel and equipment available. Such background data should, therefore, be gathered at the checkpoint for the time checkpoint activity is being observed. That is, the number of X-ray machines, front and secondary magnetometers, hand wands, and Explosive Trace Detectors (EDT) available during data collection events (see Appendix A, Form 1). The number of screeners on duty (by position) and supervisors should also be noted (Form 1), along with the volume of individuals and bags being screened (Forms 2-5). Forms 6-16 in Appendix A provide checklists for data collected against the MOPs. Each of the MOPs should be recorded under varying passenger and bag volumes (i.e., low, medium, and high) to determine if there are significant differences in screener performance between volume levels.

### 2.1 ISSUE 1. THREAT DETECTION FOR INDIVIDUALS.

Are checkpoint procedures, staffing, and equipment adequate to prevent passengers from carrying threats through the checkpoint? Does passenger volume affect detection of threat objects on individuals?

### 2.1.1 Criterion 1-1 Investigative in Nature.

MOP 1-1-1 Type and frequency of errors in front magnetometer procedures with differing volumes of people

MOP 1-1-2 Type and frequency of errors in secondary magnetometer procedures with differing volumes of people

MOP 1-1-3 Type and frequency of errors in divestment procedures with differing volumes of people

MOP 1-1-4 Type and frequency of errors in hand-wanding procedures with differing volumes of people

MOP 1-1-5 Type and frequency of errors in pat-down search procedures with differing volumes of people

MOP 1-1-6 Number of magnetometers, hand wands, X-ray machines, and EDT machines, with differing volumes of people

MOP 1-1-7 Number of screeners assigned to each function, with differing volumes of people

Data collection uses checklists 1 and 2.

## 2.2 ISSUE 2. THREAT DETECTION FOR CARRY-ONS.

Are X-ray operators, bag checkers, and trace operators effective in detecting prohibited objects in carry-on baggage?

### 2.2.1 Criterion 2-1 Projected Threats are Effectively Detected.

MOP 2-1-1 The Probability of Detection ($P_d$) for TIP data from X-ray machines with differing volumes of bags

MOP 2-1-2 The Probability of a False Alarm ($P_{fa}$) for TIP data from X-ray machines with differing volumes of bags

MOP 2-1-3 Type and frequency of errors in X-ray operations with differing volumes of bags

MOP 2-1-4 Type and frequency of errors in bag-search procedures with differing volumes of bags

MOP 2-1-5 Type and frequency of errors in trace procedures with differing volumes of bags

Data collection uses checklists for each bag-screening task to record deviations from standard procedures.

## 2.3 ISSUE 3. EXIT LANE MONITORING.

Are exit-lane monitors effective in guarding the sterile area?

### 2.3.1 Criterion 3-1 Investigative in Nature.

MOP 3-1-1 Number and durations of times the exit lane monitor is apparently less than 100% vigilant (engaged in conversation, reading, or other activities)

MOP 3-1-2 Number and durations of close physical proximity between screened and unscreened individuals

MOP 3-1-3 Circumstances accompanying an exit lane breach

MOP 3-1-4 Type and frequency of errors searching equipment, with differing volumes of people

Data collection uses a checklist for each external lane monitoring position to record deviations from standard procedures.

In addition, data collection records as many activities leading up to a breach as possible including videotapes.

## 2.4 ISSUE 4. THROUGHPUT FOR INDIVIDUAL SCREENING.

Do inefficient passenger-screening procedures contribute to low throughput?

### 2.4.1 Criterion 4-1 Investigative in Nature.

MOP 4-1-1 Amount of time to process each person through the front magnetometer with differing volumes of people

MOP 4-1-2 Amount of time to process each person through the secondary magnetometer with differing volumes of people

MOP 4-1-3 Amount of time to process each person with a hand wand with differing volumes of people

MOP 4-1-4 Amount of time to process each person with pat-down procedures with differing volumes of people

MOP 4-1-5 Type and frequency of elective procedures such as secondary magnetometer, hand wand, and pat downs with differing volumes of people

Data collection uses a checklist for each process.

## 2.5 ISSUE 5. THROUGHPUT FOR CARRY-ON BAG SCREENING.

Do inefficient baggage-screening procedures contribute to low throughput?

### 2.5.1 Criterion 5-1 Investigative in Nature.

MOP 5-1-1 Amount of time for X-ray scanning with differing volumes of bags

MOP 5-1-2 Amount of time for searching bags with differing volumes of bags

MOP 5-1-3 Amount of time for using trace on bags with differing volumes of bags

MOP 5-1-4 Amount of time people wait for their bags with differing volumes of bags

MOP 5-1-5 Type and frequency of elective procedures such as bag search and trace detection with differing volumes of bags

Data collection uses checklists to record the time it takes to clear bags at the X-ray machine, bag checking station, and the trace system.

Deviations from standard operating procedures and inefficiencies due to a lack of passenger cooperation (purposeful or inadvertent) should be recorded. Finally, gross inefficiencies of the screeners as reflected in unusually long times to perform standard procedures or an unusual frequency of time-consuming procedures should be recorded. In addition, the proportion of bags receiving a physical search or are subjected to trace procedures can be documented.

## 2.6 ISSUE 6. CHECKPOINT FLOW.

Does checkpoint layout contribute to bottlenecks?

### 2.6.1 Criterion 6-1 Passengers Go to Inappropriate Places During the Process.

MOP 6-1-1 Number of people previously screened by the front magnetometer waiting in line to unnecessarily be re-screened by the secondary magnetometer or hand wand, with differing volumes of people

MOP 6-1-2 Duration of time previously screened individuals with their screened bags spend within the checkpoint, with differing volumes of people

MOP 6-1-3 Number of individuals asking screeners and supervisors questions, with differing volumes of people

MOP 6-1-4 Directness of the route individuals take out of the screening area, with differing volumes of people

Data collection uses checklists to note how long individuals take to leave the checkpoint after they and their bags have been cleared. The checkpoint and the flow of passengers can be noted and, if able to watch video segments in a speeded mode, patterns of traffic flow will emerge revealing 'choke points' in traffic flow.

## 2.7 ISSUE 7. SUPERVISION.

Does supervision contribute to effective and/or efficient screening procedures?

### 2.7.1 Criterion 7-1 Investigative in Nature.

MOP 7-1-1 Type and frequency of errors in screening procedures corrected by supervisors, with differing volumes of people

MOP 7-1-2 Type and frequency of inefficiencies corrected by supervisors, with differing volumes of people

Data collection uses checklists to record corrected errors and inefficiencies.

## 2.8 ISSUE 8. COMMUNICATION.

Is there unnecessary or irrelevant communication between screeners?

### 2.8.1 Criterion 8-1 Investigative in Nature.

MOP 8-1-1 Number of times the X-ray operator converses while the belt is running, with differing volumes of people

MOP 8-1-2 Number of times the front magnetometer operator converses with the secondary magnetometer operator without an alarm being involved, with differing volumes of people

Data collection uses checklists to record the number of times X-ray operators, bag checkers, and front and secondary magnetometer operators engage in unnecessary or irrelevant conversation.

## 2.9 DATA COLLECTION PROTOCOLS.

The standard protocol is to unobtrusively observe the checkpoint to gather checkpoint status (passenger volume, staffing, etc.) and information about any significant occurrences in real time. The data collectors can then review video recordings of this block of time and fill out a checklist for each screener position. Data collection may require multiple sessions of real-time observation, in order to be complete and accurate, if the data collectors cannot adequately record checklist data using video recordings.

## 3. DATA ANALYSES.

Evaluators can calculate frequencies of serious errors for all procedures on the checklist forms, translating these frequencies into probabilities of serious procedural errors for a particular passenger or bag. Next, they can correlate these data with checkpoint status variables (volume, staff, etc.) to look for important variables that contribute to procedural errors. In addition, they can correlate status variables and frequencies of serious procedural errors at the X-ray operator position with TIP performance to look for important variables that may contribute to threat detection deficiencies.

Finally, they can calculate means and variances for the time to complete each checkpoint procedure. Data can be inserted into a checkpoint-processing model (see Figure 1) to analyze passenger flow and passenger delays under different checkpoint load and staffing conditions.

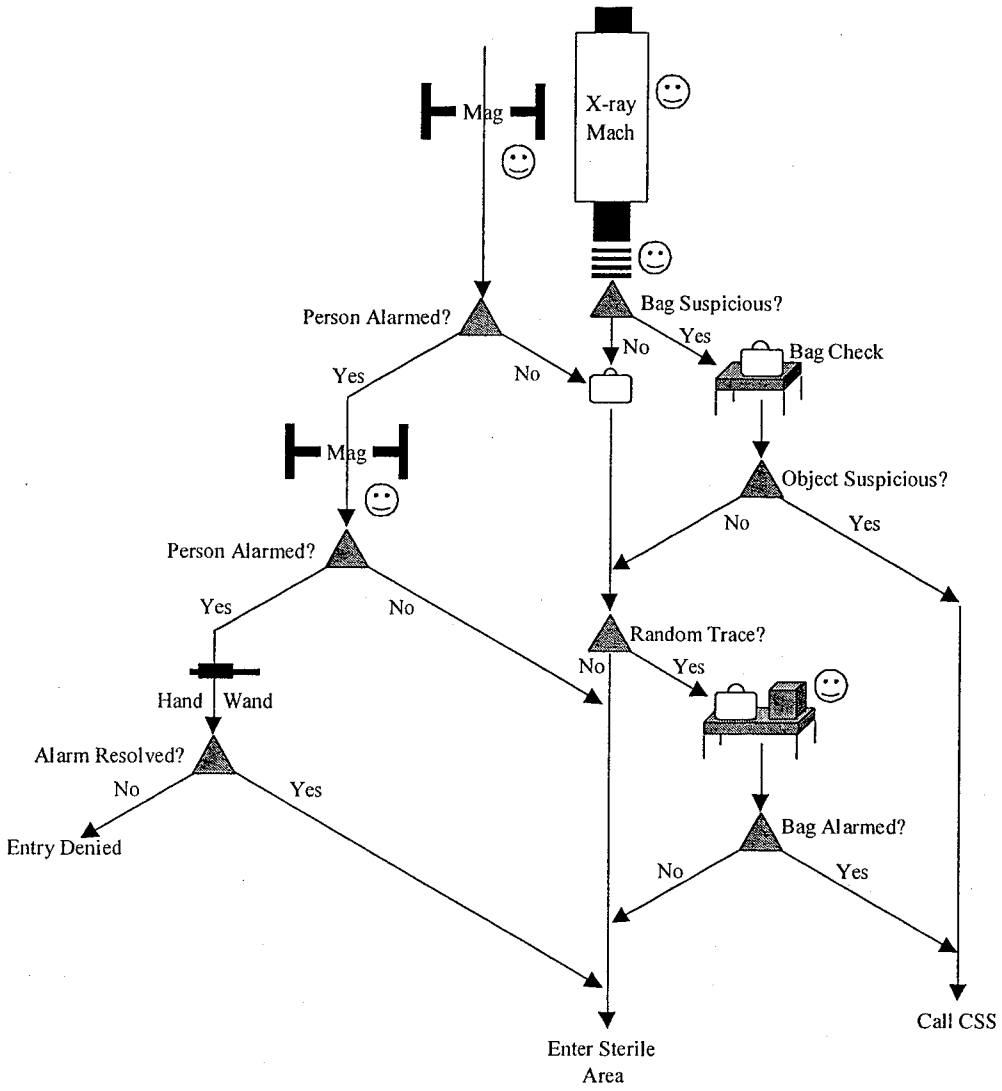


*Figure 1. Checkpoint Processing Model*

## 4. REFERENCES

[1] Fobes, J. L. & Neiderman, E. (1997*). The Training Development Process for Aviation Screeners* (DOT/FAA/AR-97/46). Atlantic City International Airport, NJ: DOT/FAA William J. Hughes Technical Center.

[2] Fobes, J. L., Neiderman, E. C., Klock, B. A., & Barrientos, J. M. *Threat Image Projection*

*User Guides for Federal Security Managers, Security Company Guard Managers, and Checkpoint Security Supervisors Using EG&G Astrophysics' Linescan X-ray Machi*nes, DOT/FAA/AR-97/80

[3] Fobes, J. L., Neiderman, E. C., Klock, B. A., & Barrientos, J. M. *Threat Image Projection User Guides for Federal Security Managers, Security Company Guard Managers, and Checkpoint Security Supervisors Using Rapiscan's X-ray Machines*, DOT/FAA/AR-97/105.

# APPENDIX A

Evaluation Checklists for Checkpoint Tasks

## Form 1

### Security Personnel and Equipment

This form is filled out as checkpoint background information on the available personnel and equipment. The data are for MOPs 1-1-6 to 1-1-7 and 4-1-5. This form should accompany each of the following data sheets.

## Form 2

## Passenger Volume

Date _____ Time _____

This form is filled out for different volumes of people passing through the checkpoint and provides data for MOPs 1-1-1 to 1-1-7, 4-1-1 to 4-1-5, 6-1-1 to 6-1-4, 7-1-1 to 7-1-2, and 8-1-1 to 8-1-2. Each row is completed for some fixed amount of time (e.g., 5 minute timing duration) and entries represent the number of occurrences for each column.

**Number of Personnel**

X-Ray Screeners _____
Bag Checkers _____
Trace Operators _____
Front Mag Operators _____
Back Mag Operators _____
Exit Lane Monitors _____
CSSs _____
Hand Wanders _____

**Amount of Equipment**

X-Ray Machines _____
Front Magnetometers _____
Back Magnetometers _____
Hand Wands _____
ETDs _____

# Passenger Volume

| Volume | Date | Start/End Time | Front Mag | Re-Mag | Secondary Mag. | Hand Wand | Pat Down | Timing Duration_____ Notes: |
|---|---|---|---|---|---|---|---|---|
| 1. Low | | | | | | | | |
| 2. Low | | | | | | | | |
| 3. Low | | | | | | | | |
| 4. Low | | | | | | | | |
| 5. Low | | | | | | | | |
| 6. Low | | | | | | | | |
| 7. Low | | | | | | | | |
| 8. Low | | | | | | | | |
| 9. Low | | | | | | | | |
| 10. Low | | | | | | | | |
| 11. High | | | | | | | | |
| 12. High | | | | | | | | |
| 13. High | | | | | | | | |
| 14. High | | | | | | | | |
| 15. High | | | | | | | | |
| 16. High | | | | | | | | |
| 17. High | | | | | | | | |
| 18. High | | | | | | | | |
| 19. High | | | | | | | | |
| 20. High | | | | | | | | |

## Form 3

### Passenger Timing

This form is filled out for the amount of time it takes for people to pass through various segments of the checkpoint and supports MOPs 4-1-1 to 4-1-4, 5-1-1 to 5-1-4, and 6-1-2. Each row is completed for some fixed amount of time (e.g., 5 minute timing duration) and entries represent the time for each column. It is difficult for a single data collector to time each of these segments for all of the people passing through. It is instead suggested that individual columns be scored, one at a time, during each sampling duration.

# Passenger Timing

| Time Interval | Date | Start/End Time | Front Magnetometer Time | Re-Mag Time | Secondary Magnetometer Time | Hand Wand Time | Pat Down Time | Timing Duration_____ **Notes:** |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
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## Form 4

## Bag Volume

This form is filled out for different volumes of bags passing through the checkpoint and provides data for MOPs 2-1-1 to 2-1-5 and 5-1-1 to 5-1-5. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column.

## Bag Volume

Timing Duration_____

| Volume | Date | Start/End Time | Number X-Rayed | Number Searched (whole/limited) | Number Traced | Notes: |
|---|---|---|---|---|---|---|
| 1. Low | | | | | | |
| 2. Low | | | | | | |
| 3. Low | | | | | | |
| 4. Low | | | | | | |
| 5. Low | | | | | | |
| 6. Low | | | | | | |
| 7. Low | | | | | | |
| 8. Low | | | | | | |
| 9. Low | | | | | | |
| 10. Low | | | | | | |
| 11. High | | | | | | |
| 12. High | | | | | | |
| 13. High | | | | | | |
| 14. High | | | | | | |
| 15. High | | | | | | |
| 16. High | | | | | | |
| 17. High | | | | | | |
| 18. High | | | | | | |
| 19. High | | | | | | |
| 20. High | | | | | | |

## Form 5

## Bag Timing

This form is filled out for the amount of time it takes for carry-on bags to pass through various segments of the checkpoint for MOPs 5-1-1 to 5-1-3. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the time for each column. It is difficult for a single data collector to time each of these segments for all of the bags passing through. It is instead suggested that individual columns be scored, one at a time, during each sampling duration.

# Bag Timing

Timing Duration_____

| Time Interval | Date | Start/End Time | X-Ray Time | Trace Time | Bag Search Time & Whole or Limited | Time Individual Waits | Notes: |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
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## Form 6

## X-ray Operations

This form is filled out for MOPs 2-1-3 and 8-1-1. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column. TIP data are later obtained from the X-ray's TIP management system which will provide the number of TIP presentations during the time of interest along with the number of detections and false alarms. The TIP management system for Rapiscan and EG&G X-ray machines is described in each of the manufacturer's users' guides [2,3].

# X-Ray Operations

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____ **X-Ray #** _____

Timing Duration_____

**Notes:**

| Time Interval | No Errors | Fails to Orient to Monitor | Conversations with Belt On | TIP $P_d$ and $P_{fa}$ | |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
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## Form 7

## Bag Search

This form is filled out for MOP 2-1-4. Each row is completed for some fixed amount of time (e.g., 5 minutes). Entries represent the number of occurrences for each column and search errors are noted.

# Bag Search (1/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | No Errors | Limited/Whole Bag Check (L/W) | Fails to Ask Permission | Fails to Maintain Control of Bag | Fails to Check All Pockets | Fails to Open Bag Toward Self | **Notes:** |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
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| 5 | | | | | | | |
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# Bag Search (2/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | Fails to Check in Circular Pattern | Fails to Check Top, Bottom, & Sides of Bag | Fails to Check Through Layers of Clothing | Fails to Check Individual Containers Within Bag | Fails to Restrict Passenger's Access to Contents of Bag | **Notes:** |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
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## Form 8

## Trace Operations

This form is filled out for MOP 2-1-5. Each row is completed for some fixed amount of time (e.g., 5 minutes). Entries represent the number of occurrences for each column and search errors are noted.

# Trace Operations

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____ **Trace Machine #** _____

Timing Duration_____

| Passenger | No Errors | Fails to Acquire Consent | Fails to Maintain Control | Fails to Carry bag by Sides | Fails to Swab Zippers, etc | Fails to Swab Handle Last | Only 1 Bag on Table | **Notes:** |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
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## Form 9

## Front Magnetometer

This form is filled out for MOP 1-1-1. A row is completed for each passenger passing through the magnetometer. Entries represent procedural errors made by the screener monitoring the front magnetometer.

# Front Magnetometer

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____ **Magnetometer #** _____

Timing Duration_____

| Passenger | No Errors | Inappropriate Items thru Mag | Fails to Check Divest Tray | Fails to Check Carried Items | Fails to Check Electronics | No Transition to 2nd Mag | Engaged in Conversation | **Notes:** |
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## Form 10

## Secondary Magnetometer

This form is filled out for MOPs 1-1-2 and 1-1-3. A row is completed for each passenger passing through the magnetometer. Entries represent procedural errors made by the screener monitoring the back magnetometer.

# Secondary Magnetometer

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____ **Magnetometer #** _____

Timing Duration_____

| Passenger | No Errors | Fails to Direct Divestiture | Fails to Direct Thru Mag | Fails to Monitor Alarm Status | Fails to Direct For Hand Wand | Fails to Direct For Pat Down | Fails to Search Divest Tray | **Notes:** |
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## Form 11

## Hand Wanding

This form is filled out for MOP 1-1-4. A row is completed for each passenger that is hand wanded. Entries represent procedural errors made by the screener performing the hand-wanding operations.

# Hand Wanding (1/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | No Errors | Fails to Ask Permission | Fails to Direct Pass. To Divest | Fails to Search Divest Tray | Fails to Test Hand Wand | Fails to Ask Pass. To Spread Arms | Touches Pass. With Hand Wand | **Notes:** |
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# Hand Wanding (2/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | Fails to Outline Body | Fails to Check Front/Back of Pass. | Fails to Positively ID Each Alarm | Fails to Resume Wanding at Alarm | Fails to Inspect Belt Buckle/Hat | Fails to Check Ankles & Back | **Notes:** |
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## Form 12

### Whole-Body Pat Down

This form is filled out for MOP 1-1-5. A row is completed for each passenger undergoing a whole-body pat down. Entries represent procedural errors made by the screener performing the pat down.

# Whole-Body Pat Down (1/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | No Errors | Fails to Ask Permission | Searched by Opposite Sex | Fails to Ask Pass. To Divest | Fails to Inspect Divest Tray | Fails to Ask Pass. To Spread Arms | Fails to Check Arms/Legs | **Notes:** |
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# Whole-Body Pat Down (2/2)

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | Fails to Use Back of Hands | Fails to Check Front/Back | Fails to Check Sides | Fails to Check Waist Area | Fails to Check Shoes/Boots | Fails to Check Crotch Area With Hand Wand | Notes: |
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## Form 13

## Exit Lane

This form is filled out for MOPs 3-1-1 to 3-1-4. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column.

# Exit Lane

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Time Interval | No Errors | Fails to Orient Self to Public Area | Duration/# of Times Not Vigilant | Duration/# of Times Screened & Unscreened in Close Proximity | # of Equipment Screened | # of Individuals Screened | **Notes** (including circumstances accompanying a breach): |
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## Form 14

## Equipment Search

This form is filled out for MOPs 3-1-4. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column.

# Equipment Search

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | No Errors | Fails to Check Seat Pan (Inside) | Fails to Check Seat Pan (Outside) | Fails to Check Seat Back (Inside) | Fails to Check Seat Back (Outside) | Fails to Check Compartments | Fails to Check Undercarriage | Fails to Check Other Component | **Notes:** |
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## Form 15

## Checkpoint Security Supervisor

This form is filled out for MOPs 7-1-1 and 7-1-2. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column.

# Checkpoint Security Supervisor

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Time Interval | No Errors | Corrects Screener Errors | Clears Special Individuals | Rotates Screeners | Tests Screeners | Fails to Dress Distinctively | **Notes:** |
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## Form 16

## Passenger Activities

This form is filled out for MOPs 6-1-1 to 6-1-4. Each row is completed for some fixed amount of time (e.g., 5 minutes) and entries represent the number of occurrences for each column.

## Passenger Activities

**Date** _____ **Start Time** _____ **End Time** _____ **Traffic Volume** _____

Timing Duration_____

| Passenger | No Inefficiencies | Waiting for Family/Friends, Arranging Bags, Etc. | Didn't Take Most Direct Route Out of Checkpoint | Stood in Back Mag. Line Unnecessarily | Asked Screeners/ CSS Questions | Amount of Time Spent in Checkpoint With Their Bags | **Notes:** |
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