

DOT/FAA/AR-00/7

Office of Aviation Research
Washington, DC 20591

Checkpoint Effectiveness and Efficiency Evaluation

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October 1999

Final Report

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Technical Report Documentation Page

1. Report No. DOT/FAA/AR-00/7		2. Government Accession No.		3. Recipient's Catalog No.	
1. Title and Subtitle Checkpoint Effectiveness and Efficiency Evaluation		5. Report Date October 1999		6. Performing Organization Code AAR-510	
		8. Performing Organization Report No. DOT/FAA/AR-99/XX			
7. Author(s) J. L. Fobes, Ph.D., Michael D. Snyder, & Brenda A. Klock		10. Work Unit No. (TRAIS)		11. Contract or Grant No.	
9. Performing Organization Name and Address U.S. Department of Transportation, Federal Aviation Administration William J. Hughes Technical Center Atlantic City International Airport, NJ 08405		13. Type of Report and Period Covered		14. Sponsoring Agency Code ACS-1	
		10. Work Unit No. (TRAIS)		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address U.S. Department of Transportation, Federal Aviation Administration Associate Administrator of Civil Aviation Security, ACS-1 800 Independence Ave., S.W. Washington, DC 20590		15. Supplementary Notes:			
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.					
17. Key Words Aviation Security Airport Checkpoint		18. Distribution Statement This report is approved for public release and is on file at the William J. Hughes Technical Center, Aviation Security Research and Development Library, Atlantic City International Airport, NJ 08405. This document is also available to the U.S. public through the National Technical Information Service (NTIS), Springfield, VA 22161.			
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 35	22. Price

Form DOT F 1700.7 (8-72)

Reproduction of completed page authorized

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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 (detering 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.

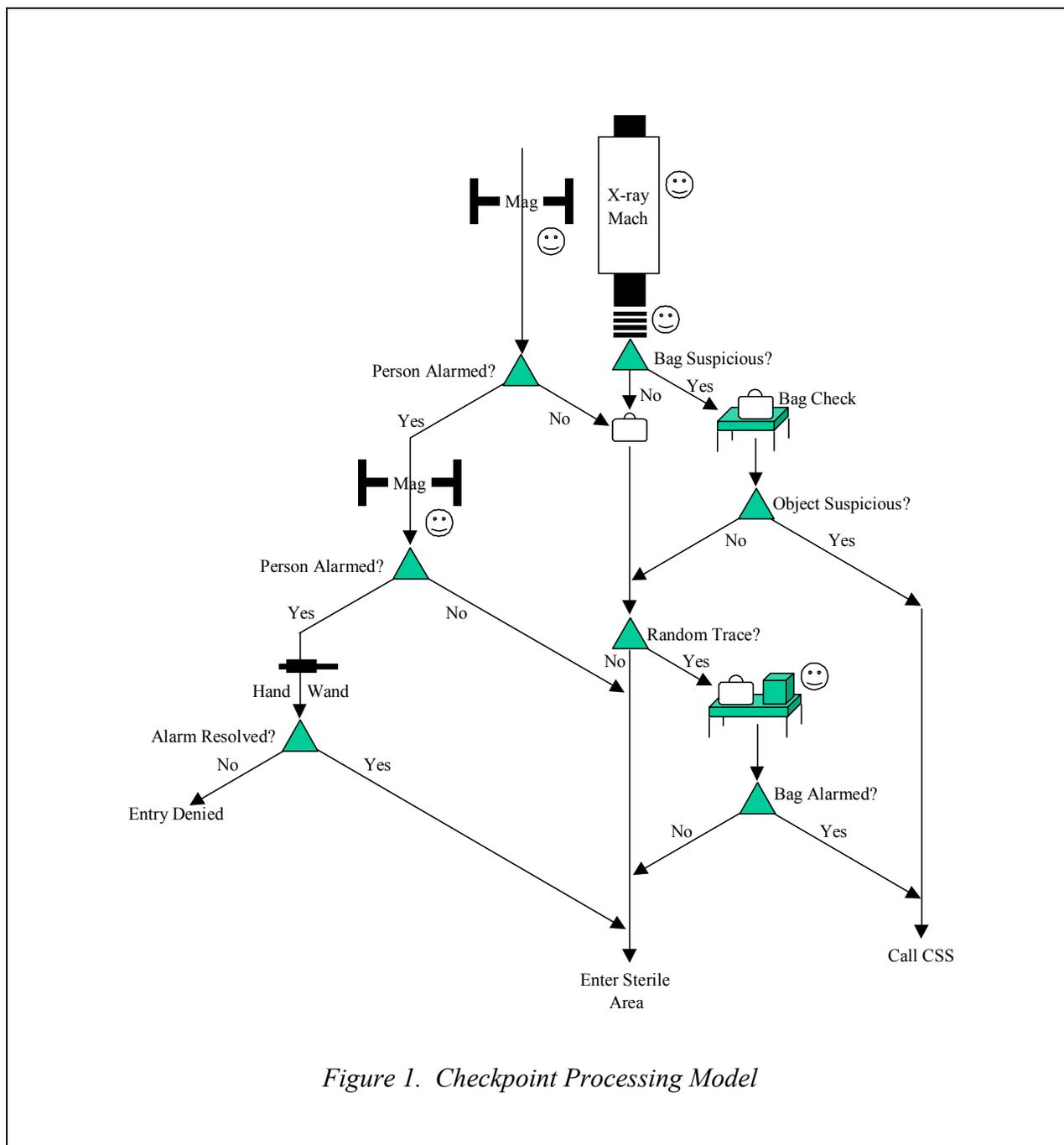


Figure 1. Checkpoint Processing Model

4. REFERENCES

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- [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 Machines, 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									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									

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

Volume	Date	Start/End Time	Number X-Rayed	Number Searched (whole/limited)	Number Traced	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 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

Time Interval	Date	Start/End Time	X-Ray Time	Trace Time	Bag Search Time & Whole or Limited	Time Individual Waits	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Timing Duration _____

Notes:

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 # _____

Time Interval	No Errors	Fails to Orient to Monitor	Conversations with Belt On	TIP P _d and P _{fa}	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					

Timing Duration _____

Notes:

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 _____

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	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							

Timing Duration _____

Notes:

Bag Search (2/2)

Date _____ Start Time _____ End Time _____ Traffic Volume _____

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	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
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26						
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29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						

Timing Duration _____

Notes:

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 # _____

Passenger	No Errors	Fails to Acquire Consent	Fails to Maintain Control	Fails to Carry bag by Sides	Fails to Swab Zippers, etc	Only 1 Bag on Table	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
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26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							

Timing Duration _____

Notes:

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 # _____

Passenger	No Errors	Inappropriate Items thru Mag	Fails to Check Divest Tray	Fails to Check Carried Items	No Transition to 2nd Mag	Engaged in Conversation	Timing Duration _____	Notes:
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
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36								
37								
38								
39								

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 # _____

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	Timing Duration _____	Notes:
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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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 _____

Passenger	No Errors	Fails to Ask Permission	Fails to Direct Pass. To Divest	Fails to Search Divest Tray	Fails to Test Hand Wand	Touches Pass. To Spread Arms	Touches Pass. With Hand Wand	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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Timing Duration _____

Notes:

Hand Wanding (2/2)

Date _____ Start Time _____ End Time _____ Traffic Volume _____

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

Timing Duration _____

Notes:

Passenger							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
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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 _____

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	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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Timing Duration _____

Notes:

Whole-Body Pat Down (2/2)

Date _____ Start Time _____ End Time _____ Traffic Volume _____

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	
1							
2							
3							
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39							

Timing Duration _____

Notes:

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 _____

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):
1							
2							
3							
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Timing Duration _____

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 _____

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
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Timing Duration _____

Notes:

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 _____

Time Interval	No Errors	Corrects Screener Errors	Clears Special Individuals	Rotates Screeners	Tests Screeners	Fails to Dress Distinctively	Notes:
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Timing Duration _____

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 _____

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