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Systems Analysis of the Federal Aviation Administration's K-9 Program

Stephen Cormier, Ph.D.
J.L. Fobes, Ph.D.
Susan F. Hallowell, Ph.D.
J. Michael Barrientos

Aviation Security Human
Factors Program, AAR-510
FAA Technical Center
Atlantic City International Airport, NJ 08405

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Stephen Cormier, Ph.D., J. L. Fobes, Ph.D., S. F. Hallowell, Ph.D., and J. M. Barrientos, of the Federal Aviation Administration (FAA), and D. S. Fischer, A. M. Prestrude, Ph.D., J. O'Shea, D. Weitzman, and R. M. Malone, of Galaxy Scientific Corporation (GSC).	

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16. Abstract

The Federal Aviation Administration's (FAA) K-9 Program has been a formal program within the FAA for over 23 years. The local law enforcement uses FAA sponsored K-9 teams to search the aircraft operations area (AOA) at U.S. airports for clandestine explosives if a threat has been indicated. K-9 explosive detection teams are the only mobile detection system currently employed by the FAA for the detection of explosives within the AOA. The FAA has sponsored an initiative to improve effective training techniques for the dogs, handlers, and K-9 teams.

The FAA K-9 Program is a complex system consisting of three subsystems: initial training, operational training, and annual certifications. The analysis required that each subsystem be observed, potential problems identified, and solutions recommended to strengthen the program.

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PREFACE

This document describes the methods and procedures used to train and certify K-9 teams for the Federal Aviation Administration's (FAA) K-9 Program. The evaluation activities completed to date are included in this report. This study was conducted in support of the Aviation Security Human Factors Program at the FAA Technical Center, Atlantic City International Airport, New Jersey. The key FAA personnel supporting this study are J. L. Fobes, Ph.D., Aviation Security Human Factors Program Manager; Susan F. Hallowell, Ph.D., Research Chemist; S. Cormier, Ph.D., Engineering Research Psychologist; and J. Michael Barrientos, Technical Specialist; all employed with the Aviation Security Research and Development Division.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACO	Office of Civil Aviation Security Operations
ACS	Office of the Associate Administrator for Civil Aviation Security
AFB	Air Force Base
ANOVA	Analysis of Variance
AOA	Aircraft Operations Area
FAA	Federal Aviation Administration
KSA	Knowledge, Skill, and Ability
MWDTS	Military Working Dog Training School
P_d	Probability of Detection

EXECUTIVE SUMMARY

The Federal Aviation Administration's (FAA) K-9 Program has been a formal program within the FAA for over 23 years. The local law enforcement uses FAA sponsored K-9 teams to search for explosives in aircraft operations areas (AOAs) at U.S. airports if a threat has been declared. At the present time K-9 explosives detection teams are the only mobile detection system used by the FAA to detect explosives where accessibility is difficult (i.e. overhead bins in an aircraft cabin).

The FAA K-9 Program is a system consisting of initial training, operational training, and annual certification that is used to establish and maintain proficiency in the detection of explosives. A systems analysis was conducted on the FAA K-9 Program to examine current training and certification practices and to identify effective training and testing methods for both the dog and handler for the detection of explosives. The systems analysis included observing initial training, maintenance training, and annual certification procedures.

Dogs used in FAA sponsored K-9 teams are trained by the 341st Military Working Dog Training School (MWDTS) at Lackland Air Force Base in San Antonio, Texas. An important aspect of this program is the fact that FAA dogs are not dedicated solely to the FAA, rather. Rather the dogs are maintained and used by local law enforcement agencies. There are such 92 K-9 teams available in 31 U.S. cities. Each participating city is required to have at least two teams that meet FAA certification standards. The dogs in the program may be owned by the FAA or by the city participating in the FAA K-9 Program. FAA-owned dogs and city-owned dogs are maintained by local law enforcement agencies who are committed to serving the FAA as their first priority. The FAA K-9 Program is a volunteer program with local enforcement agencies. As such, the FAA agrees to provide initial training for both dogs and handlers and agrees to support the veterinary needs of the dogs.

Potential concerns identified in the existing K-9 Program include the following: -

a. Dogs only receive explosives detection task training (i.e., single purpose training). Dogs should be trained on more than one task (i.e., dual purpose training) to increase working confidence, problem solving skills, agility, and the dog/handler bond.

b. Dogs are not trained in situations with typical types of distracting stimuli that are found in a search environment (e.g., noises, stray food, etc.). Some attention to distractors is normal, but problems can arise from anxiety or fixations on distracting stimuli.

c. The FAA K-9 Program is essentially a volunteer program. As such there are no handler selection criteria to control the required characteristics of handlers. Lack of selection criteria for handlers leaves the FAA Program vulnerable to training individuals who are not qualified to handle dogs.

d. The amount of time the cities spend on maintenance training is dependent upon available city funds. This may affect the quality of the recurrent training provided to the field teams and the overall effectiveness of the K-9 units.

e. Some agencies do not have enough personnel who are experienced in training K-9 units to detect explosives. The result is that some K-9 team members may have to work overtime to train the less experienced K-9 teams.

f. The evaluations are conducted late at night so that there will be no interference with the normal airport operations. However, these circumstances typically resulted in an area free of distractions, which is not representative of normal airport operations.

g. There are no standard procedures for conducting certifications. The experience of the evaluators and testing conditions determine where explosive training aids will be hidden. Further, while a given evaluator may use similar procedures for all evaluations, the procedures may vary between the various 341st MWDTS evaluator teams.

h. Cross-contamination of explosives may occur from improper handling, storage, or shipping techniques. Cross-contamination may affect the quality of training because the odors from highly odorous explosive training aids may by the dominant odor on other training aides, thus effectively training the K-9 on only a single (dominant) scent.

Recommendations to strengthen the K-9 Program are provided at the conclusion of the report.

1. INTRODUCTION.

Over the past decade, terrorists have increased the threat to aircraft through sabotage by bombings. This was highlighted dramatically by the Pan American flight 103 disaster. Sophisticated terrorists can build and disguise improvised explosive devices that are capable of destroying an aircraft and killing hundreds of people. As part of an ongoing program to counter terrorist bombings, the Federal Aviation Administration (FAA) is supporting the development of systems to detect these explosive devices. Yeaple (1991) evaluated the status of explosives detection technology and concluded that "the technology of terrorism has outpaced airport security." New detection technologies are being developed and tested, but, according to Lovett (1992), a dog's nose may be the best detector of explosives. While most detection devices are large, fixed-based, and expensive, dogs offer a mobile, relatively inexpensive, explosives detection system that has been field tested for many years (Carr-Harris and Thal, 1970; Nolan and Gravitte, 1977; Eastwood, 1990; Francis, 1990a; and Francis, 1990b). It should be noted that dogs are often used to verify whether or not the contents of a suspicious baggage item (as identified by screeners or X-ray equipment) contain explosives.

Until recently, most of the evidence for a dog's keen sense of smell was anecdotal. Comparative anatomical studies, however, indicate that dogs have a highly developed olfactory apparatus (Lovett, 1992; Chao, 1977; Coile, in preparation; and Syrotuck, 1972). Mitchell (1976) indicates that dogs' olfactory sensorium is highly selective and appears to be sensitive to small quantities of relevant target substances. Mitchell indicates that dogs can successfully demonstrate olfactory discrimination through operant conditioning principles. The success of dogs in tracking and detecting contraband items and explosives suggests that they are capable of ignoring distractions and attending to signal odorants. Regardless, not much is known about the dog's sensitivity to odor intensity.

The explosives detection training sequence is both time consuming and expensive, and it is an inevitable fact of biological variability that not all K-9 candidates will successfully complete training (Mitchell, 1976). A certain proportion of trainees will be rejected for physical and medical reasons, while others will lack motivation or possess incompatible temperaments. In view of these considerations, the FAA K-9 Program is designed to select appropriate dogs, train them to detect explosive scents that are characteristic of terrorist weapons, and evaluate their performance in meeting requirements. A priority of the FAA is to ensure that the operational K-9 teams are proficient in detecting explosives and that annual certification rates are valid measures of the K-9 team's ability to detect explosives.

Under the auspices of the FAA's Office of Civil Aviation Security Operations (ACO), the FAA K-9 Explosives Detection Team Program has been in existence for over 23 years. The FAA has trained handlers and dogs currently deployed as K-9 teams at 31 airports throughout the United States. The airports use the K-9 teams to search aircraft, vehicles, and freight and baggage areas in the event of an alert. When a threat is declared, local law enforcement agencies use FAA sponsored K-9 teams to search the aircraft operations area (AOA) at U.S. airports for clandestine explosives. The main priority of the K-9 teams is to provide a 30-minute or less response time to their respective airport should a threat be received. The second priority is to be able to be sent anywhere in the country should an aircraft be in-flight and have received a threat. Unfortunately, over the past several years, the program has experienced problems with maintaining the

proficiency of these teams. Performance records show that explosives detection dogs and their handlers have exhibited detection decrements in the field. *The Dog Report* (Travers and Willett, 1991) indicates that the average certification rates for K-9 teams was 17 percent in 1991, and were below 70 percent starting in 1988. The report also indicates that the methods used for training and certifying the teams may have been the cause of this dramatic decline in team proficiency.

Changes to the FAA K-9 Program have increased certification rates of K-9 teams over that experienced in 1991 (i.e., 87 percent in 1992, 93 percent in 1993, and 85 percent in 1994, according to Lackland Air Force Base [AFB], 341st Military Working Dog Training School [MWDTS]). Recently, Public Law 101-45 mandated that the FAA review its explosives detection procedures and initiate research to evaluate various forms of explosives detection technologies, including explosives detection K-9 teams. The Office of the Associate Administrator for Civil Aviation Security (ACS) sponsored an initiative to quantify and improve the capabilities and limitations of dogs employed for explosives detection uses and provide options for future uses. Part of this initiative includes a systems analysis of the FAA K-9 Program, which includes initial training, operational training, and certification processes.

1.1 Purpose.

This document provides the results of the systems analysis of the FAA K-9 explosives detection program. The systems analysis examined current FAA K-9 training and certification practices and identified effective explosives detection training and testing methods for both the dog and handler. Conclusions and recommendations are provided in this report to strengthen the program.

The role of human factors in a systems analysis is to help ensure that the interface between the human and other system components is as effective and efficient as possible. This outcome is accomplished through a systematic application of relevant information about human capabilities, limitations, and behaviors to the design of things and procedures that people use and the environments in which they use them (Sanders and McCormick, 1987). The role of human factors is critically important in the FAA K-9 Program, since the detection of explosives depends heavily on the handler's interaction with the dog and his or her interpretation of the dog's behavior.

The K-9 Program systems analysis consisted of a records review of the K-9 program and three operational site visits. The first visit was to the 341st MWDTS at Lackland AFB to observe procurement and initial training procedures. The second visit was to Tulsa, Oklahoma, to observe the annual certification of two K-9 teams. The third trip was to Pittsburgh, Pennsylvania, to observe operational training of three K-9 teams.

1.2 Overview of the Current System.

FAA K-9 teams are trained by the 341st MWDTS at Lackland AFB, San Antonio, Texas. The FAA has 92 K-9 teams available in 31 U.S. cities. Each participating city is required to have at least two teams that meet FAA certification standards. The dogs in the program may be owned by the FAA or owned by the city participating in the FAA K-9 Program. FAA-owned dogs and city-owned dogs are maintained by local law enforcement agencies who are committed to serving the FAA as their first priority. The FAA K-9 Program is a volunteer program with local enforcement agencies. As such, the FAA agrees to provide initial training for both dogs and handlers and to support the veterinary needs of the dogs.

The primary dog breeds used in the K-9 Program are Labradors, German Shepherds, and Belgian Malenois. The majority of the dogs are male; however, both male and female dogs are neutered prior to training to reduce distractions that may interfere with performance. All dogs in the program are trained to detect nine types of explosives. These explosives, referred to as explosive training aids, are intended to duplicate as closely as possible the odors commonly found in conjunction with explosive devices made by terrorists.

Major areas of the program include dog procurement, initial dog training, operational training, and annual certification. Brief descriptions of the components of the training process are provided in the remaining paragraphs of this overview. More detailed descriptions can be found in Section 2.

1.2.1 Subsystem 1 - Initial Training.

The objective of initial training is to train dogs and handlers to work as part of an explosives detection team. The 341st MWDTS conducts procurement and initial training activities for the FAA K-9 Program. The mission of the 341st MWDTS is to procure, train, and distribute military working dogs to satisfy explosives detection needs, to train handlers to meet all user requirements, and to provide full service, veterinary medical and surgical care to all dogs assigned to Lackland AFB. The 341st MWDTS is divided into three groups: Logistics Flight, Operations Flight, and Veterinary Services. Logistics Flight procures dogs for the program, maintains them during initial training, and ships the trained dogs to participating cities. Operations Flight trains both dogs and handlers. Only those dogs that successfully pass behavioral, physical, and performance criteria are accepted into the FAA K-9 Program. The dogs complete approximately 8 weeks of training, while the handlers complete approximately 6 weeks of training. Operations Flight also conducts annual certifications on the FAA K-9 teams to ensure that the teams can locate clandestine explosives. Veterinary Services provides medical care for all FAA dogs, including surgery, radiology, internal medicine, dentistry, and emergency care. These services are offered during the entire time that the dogs are used in service.

1.2.2 Subsystem 2 - Operational Training.

K-9 team operational training is conducted by the city participating in the K-9 Program and begins approximately 30 days after the dog arrives. The objective of operational training is to ensure that K-9 teams become proficient in detecting explosives hidden in the operational AOA and to maintain this proficiency during the K-9 team's tenure in the program. Of the dogs that are

currently part of the FAA K-9 Program, 68 percent are FAA dogs that were procured and trained by the 341st MWDTS and the other 32 percent are city-owned dogs that were procured and trained by local organizations. The organizations that employ the K-9 teams consist of law enforcement agencies and airport authorities who participate in the program on a voluntary basis and report directly to the FAA. While the FAA K-9 teams can be used to support the individual needs of the participating city, they must first respond to the needs of the FAA.

1.2.3 Subsystem 3 - Annual Certification.

Because the 341st MWDTS has only partial control over operational training, they conduct annual evaluations and reevaluations of all teams participating in the K-9 Program. The objective of the annual certification process is to evaluate the performance of trained K-9 teams and to ensure that the operational explosives detection tasks are being carried out in the expected manner and standard. The 341st MWDTS conducts the evaluations with the cities of the respective K-9 teams every year between March and June. Annual certification occurs at least 6 months after the initial certification and lasts a maximum of 7 days. Evaluations are conducted in the airports at the operational sites and requires the K-9 teams to detect a minimum of 26 out of the 28 explosive training aids hidden in the AOA. Thus, to pass the evaluation, detection teams must obtain a minimum accuracy score of at least 92.3 percent. Any K-9 team scoring less than 92.3 will be reevaluated 6 months after the failed evaluation test. As shown in Figure 1, teams that do not successfully pass the certification evaluation must participate in a reevaluation. If a detection team fails the reevaluation more than twice, they are either removed from the program or required to attend specialized training with the 341st MWDTS. Figure 1 on the following presents a model of the FAA K-9 Program.

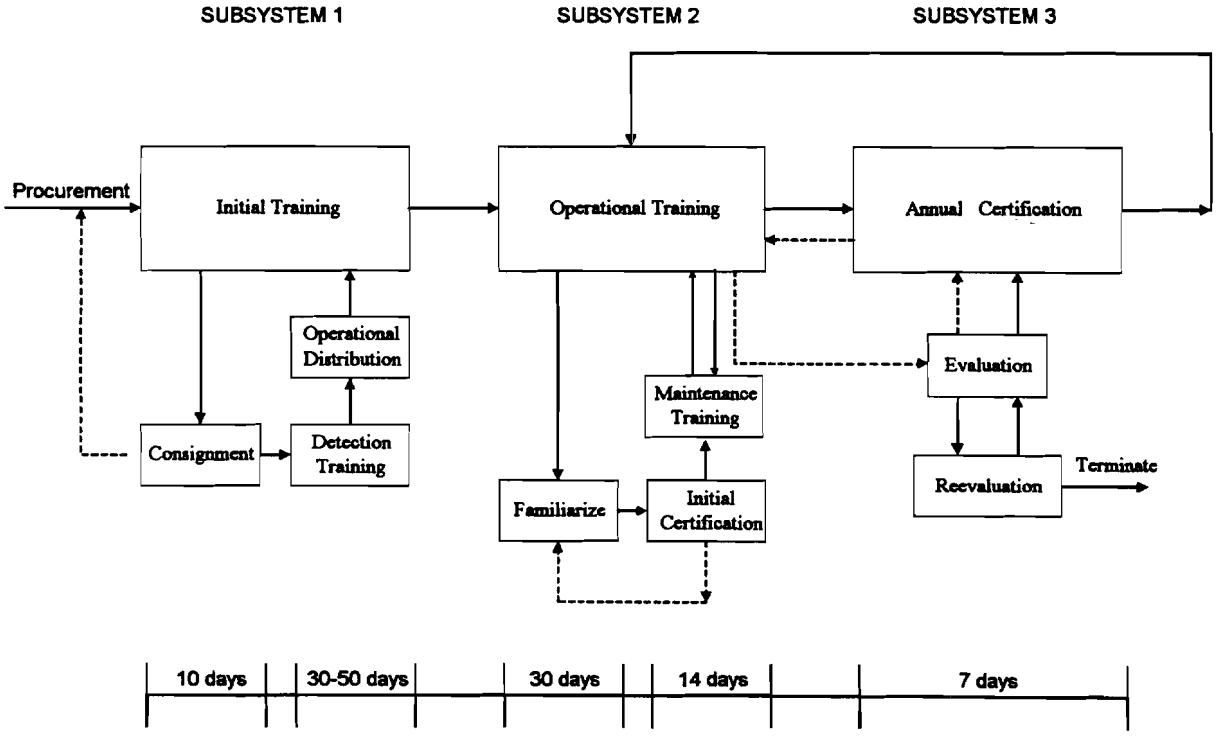


FIGURE 1. Current FAA K-9 Program And Timeline

2. DETAILED DESCRIPTION OF TRAINING COMPONENTS.

2.1 Subsystem 1 - Initial Training.

The FAA dogs and handlers are trained at the 341st MWDTS which began in 1942 at Fort Carson Army Post, Colorado. In 1958, the 341st MWDTS transferred to their current location at Lackland AFB. As previously shown in Figure 1, the primary functions that the 341st MWDTS carries out during initial training are as follows:

a. Function 1 - Procurement. Conduct behavioral and medical evaluations.

b. Function 2 - Consignment. Train dogs to detect a minimum of one scent.

c. Function 3 - Detection Training. Provide detailed detection training for both dogs and dog handlers.

d. Function 4 - Operational Distribution. Pair dogs and handlers to form operational teams.

The following sections describe these four functions.

2.1.1 Function 1 - Procurement.

Procurement is the first function that the 341st MWDTS completes when training dogs to detect explosives. Procurement consists of medical and behavioral evaluations conducted by training and veterinary personnel. The 341st MWDTS obtains dogs from several dog vendors across the United States.

The first procurement process is behavioral testing conducted to determine the dog's primary reward (the reward that best reinforces positive behavior). The primary rewards offered by the 341st MWDTS include rubber balls, kong balls, or food. (A kong ball is an oblong rubber ball that bounces erratically.) The primary reward must consistently maintain the desired behavior of sniffing and searching for an olfactory cue.

Evaluators also assess the strength of the reward by observing the dog's reaction to it when distractions are present. For example, evaluators will note how the dog reacts to a reward in a distracting setting. If the dog returns to the evaluator for another reward, the reward will be used as a primary reward. If the dog wanders away and seems uninterested in the reward, the reward will not be used again.

The 341st MWDTS finally conducts medical examinations on the dogs to ensure that they meet specific medical requirements. If a dog fails any stage of the procurement process, it is returned to the vendor and is rejected from further consideration in the K-9 Program.

Although the procurement function was not observed, a detailed task analysis is provided in Appendix A. The information was obtained through interviews with personnel assigned to the 341st MWDTS.

2.1.2 Function 2 - Consignment.

Upon completing procurement, the 341st MWDTS administers a 10-day evaluation to each dog prior to purchase. This period is known as consignment during which dogs are trained to detect a minimum of one explosive scent (i.e., explosive training aid). The 341st MWDTS uses the 4-hole scent box method, developed by Dan J. Craig, D.V.M., to train dogs to detect explosives. Dogs that successfully detect one explosive scent within 10 working days are accepted in the K-9 Program. Dogs that are unable to detect the scent within 10 working days are returned to the dog vendors and are denied consideration for further involvement in the K-9 Program. The protocol and task analysis of the 4-hole scent box training are included in Appendix B.

2.1.3 Function 3 - Initial Detection Training.

The 341st MWDTS trains dogs and handlers to work in the explosives detection team. Figure 2 provides a model of the training that the dogs and handlers receive. The handlers receive both patrol dog training (block 1) and explosives detection training (block 2). Dogs receive their own initial explosives detection training and are not paired with a handler until that is complete.

The dogs receive scent box training and open area training for the nine types of explosive training aids. (A detailed description of open area training is provided in Appendix B.) The dog's training time averages 40 working days. The length of training depends on how quickly the dog can pass the criteria, as specified by the 4-hole scent box and open area training requirements (see Appendix B). The handlers' training lasts for 12 weeks (6 weeks per block). Handlers are initially trained with experienced dogs. At the end of training, dogs are paired with handlers to form operational teams. The protocol and a task analysis of the initial explosives detection training (i.e., 4-hole scent box) are provided in Appendix B.

The 341st MWDTS provides handlers with training guides for both patrol and explosives detection. The Military Working Dog (MWD) Training Guide provides an overview of dog handling techniques, search techniques, explosive and chemical safety, legal considerations, and utilization of records. The training guide is used to reinforce lectures and study assignments. Following each lesson in the training guide are questions that trainees can use to reinforce the material covered in each block of training.

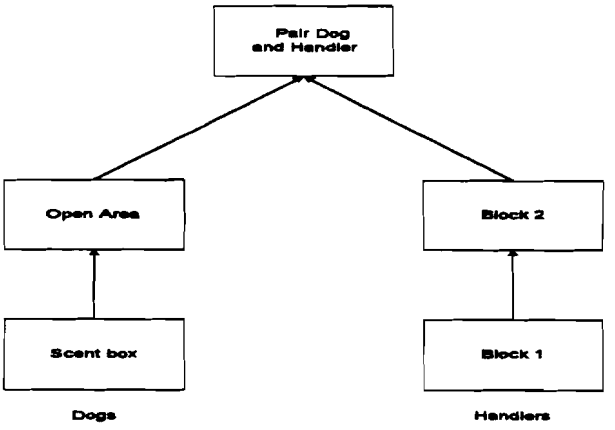


FIGURE 2. Training Tracks For Dogs And Handlers

Handler training was not observed. The information presented was obtained through interviews with personnel assigned to the 341st MWDTS.

2.1.4 Function 4 - Distribution.

Distribution is the final function that the 341st MWDTS performs. Once the dogs and handlers have completed the initial explosives detection training, operational K-9 teams are formed. The handlers are allowed to choose a K-9 partner based on dog training performance records and the handler's ability to establish a bond with an available dog. The K-9 team assignments are based on experience and on observations of dog and handler performance in training. Once the team is formed, one week of personalized explosives detection training is provided to ensure that the handler and dog can function successfully.

This function was not observed during the site visit. The information presented was obtained through interviews with personnel assigned to the 341st MWDTS.

2.2 Subsystem 2 - Operational Training.

Once they are assigned to a city, K-9 teams receive continuous operational explosives detection training for the duration of their tenure in the K-9 Program. Operational training is provided by the cities participating in the K-9 Program. The 341st MWDTS is responsible for ensuring that the dogs become acclimated to their new living environment, the teams obtain initial certification for explosives detection in the operational setting, and that the K-9 teams maintain proficiency in detecting explosives. As shown in Figure 1, the cities and the 341st MWDTS must carry out the following functions to administer operational training:

a. Function 5 - Familiarization Period. Provide time for dogs to adjust to the new environment.

b. Function 6 - Initial Certification. Train and certify K-9 teams to detect explosives in the operational environment.

c. Function 7 - Maintenance Training. Maintain K-9 team proficiency in detecting explosives in the operational environment.

The following sections describe these three functions in detail. Functions 5 and 6 were not observed during the site visits. The presented information was gathered through interviews with the 341st MWDTS and the observed operational K-9 teams.

2.2.1 Function 5 - Familiarization Period.

When a participating city receives a newly trained dog and handler, the team first completes a familiarization period (see Figure 1), which lasts an average of 60 days. The first 30 days provides time for the dog to acclimate to the new environment, establish rapport with a new handler, and adjust to the airport environment. The 341st MWDTS recommends that K-9 teams dedicate the next 30 days to training in the AOA. During this training, the dog is introduced to the operational areas and the distractions that accompany them. No training is conducted during the first 30 days of the familiarization period.

2.2.2 Function 6 - Initial Certification.

After the K-9 team has become familiarized with the new environment and has received initial area training, the 341st MWDTS conducts a 14-day training mission to train the K-9 teams to detect the nine explosive training aids in the operational areas. The explosive training aids are the same types of explosives used during initial training at Lackland AFB. At the end of the training mission, the 341st MWDTS conducts an initial certification evaluation of the K-9 team in detecting clandestine explosive training aids. If a K-9 team is unable to pass the initial certification, the 341st MWDTS will return on a later date and conduct a second 14-day training mission and initial certification.

This function was not observed during the site visits. The information presented was obtained through interviews with personnel assigned to the 341st MWDTS.

2.2.3 Function 7 - Maintenance Training.

Upon receiving initial certification, the K-9 teams train to maintain explosives detection performance (see Figure 1). The FAA requires a minimum of 4 hours of training per week. On-site maintenance training continues for the duration of a K-9 team's tenure in the FAA K-9 Program. A K-9 team will practice detecting the nine types of explosive training aids hidden in the same or similar environment to that in which the detector team will be required to work (i.e., terminal, aircraft, luggage, warehouse, vehicle). The practicing team is not present in the area when the explosives are hidden. Personnel handling the explosives include other K-9 team members or city personnel specifically assigned to handle the explosives (A detailed task analysis of the maintenance training for the five operational areas is provided in Appendix C).

Detection training in the operational setting is a complex task that must be regulated and monitored on regular schedules. Maintenance training is the basis for ensuring that the initial stages of training are permanently shaped in the dog's working behavior. Handlers ensure that the training exercises do not become routine. They also track the dog's performance during each training session. The actual exercises are supposed to be varied so that the teams do not become accustomed to a repetitious pattern. For instance, the 341st MWDTS recommends varying the general training area; the type, amount, and number of training aids planted; the specific locations of the training aids within the training area; the amount of substance used in an aid; and the time of day when training is conducted.

2.3 Subsystem 3 - Annual Certification.

The FAA evaluates and reevaluates K-9 teams annually. The 341st MWDTS conducts annual certification evaluations of all FAA K-9 teams to determine if the dog knows the target odors, whether the handler can read the dog, and can the team find explosives consistently. Currently, annual certification evaluations are the only means by which the FAA can monitor K-9 team performance.

The certification evaluations last 7 days, during which time the K-9 teams must find a minimum of 26 explosive training aids hidden in the five operational areas. To conduct an evaluation in a specific area, the 341st MWDTS hide the explosive training aids. The same explosives used for operational training are used for the certification evaluations. Before hiding the explosives, the K-9 teams are instructed to clear the area. The K-9 teams are notified over their police radios when all training aids are in place.

K-9 teams must detect a minimum of 92.3% of the hidden explosive training aids to pass the certification. A K-9 team will fail the certification evaluation if it misses more than two explosive training aids, or obtains two false alarm responses in a given area or five handler-induced false alarm responses during the entire evaluation process. A missed explosive aid due to handler error will be counted as a missed aid in calculating the overall percentage. One aid or procedure can be retested if the 341st MWDTS evaluators believe that the team's overall performance has been acceptable. The results of the retest will be included in annual evaluation statistics for the certification process. If a team fails a specified retest, it will be required to participate in a certification reevaluation. During reevaluations, only the failed areas will be retested. If the evaluators encounter recurrent deficiencies, the team will be considered decertified in all areas. If a team fails two consecutive annual certifications due to handler error, the handler will not remain in the FAA program.

As shown previously in Figure 1, the two primary functions that the 341st MWDTS and the operational K-9 team must carry out during annual evaluations include the following:

a. Function 8 - Evaluation. Evaluate the performance of trained K-9 teams to ensure that the operational explosives detection tasks are being carried out in the manner and standard expected.

b. Function 9 - Reevaluation. Reevaluate those teams that were not successful in completing the annual certification.

These two functions are described in more detail in the following sections.

2.3.1 Function 8 - Evaluation.

The 341st MWDTS evaluates K-9 teams in the five areas of the AOA for which they are trained and responsible for securing. Before conducting an evaluation in any of the five areas, the 341st MWDTS hides the nine explosive training aids. The location of the hidden explosives is determined by the evaluator's experience. Thus, the difficulty of an evaluation is based on testing conditions and decisions of the evaluators (Detailed task analyses of the evaluation searches are provided in Appendix C).

2.3.2 Function 9 - Reevaluation.

If a team fails an evaluation, a reevaluation is conducted 3 to 4 months later. During the reevaluation, only one failed area(s) is retested. This decision is made at the discretion of the evaluators. The same task analyses provided in Appendix C apply for the reevaluation.

3. ANNUAL CERTIFICATION DATA ANALYSES.

The FAA K-9 annual certification records are analyzed to identify factors that may influence a K-9 team's overall certification ratings and their performance in detecting individual explosive training aids. Several one-way analyses of variance (ANOVAs) were conducted. The independent variables included participating airport, FAA region, breed of dog, and the Lackland evaluator team. The dependent variables included certification ratings indicating a K-9 team's overall performance detecting hidden explosive training aids and their probability of detection (P_d) for specific explosive training aids. The certification ratings were determined by dividing the number of explosives detected by the number of explosives hidden, and then multiplying the quotient by 100 to obtain a percentage. The P_d scores for each explosive training aid were determined by dividing the number of explosives detected by the number hidden. Appendix D, Tables D1 through D7, show the mean certification ratings and P_d scores as a function of airport, region, dog age, breed, and Lackland evaluator team. (Region was used as a factor in order to assess whether temperature/humidity variations played a significant role in performance.) Tables D-8 and D-9 show the ANOVA results testing the significance of selected factors with certification rating, while Table D-10 shows the relationship between dog age and certification rating.

3.1 Certification Ratings.

The ANOVAs showed that there were no significant effects from the participating airport, FAA region, breed of dog, or Lackland evaluator team on certification ratings (see Appendix D, Table D-8). Further, as shown in Table D-10, a Pearson R correlation indicates there was no relationship between age of dog and certification rating. These results may be the consequence of a restricted range of certification scores. It is quite possible too, that age-related decrements in olfactory performance do not occur until a dog is truly old by which time they've been retired from the program anyway. As shown in Table D-1, the mean certification ratings across airports ranged from 70.00 to 100.00. Of the 72 teams evaluated, only 8 did not pass the certification. The minimum passing score for certification is 92.30 (26 of 28 targets).

3.2 Explosive Training Aid Probability of Detection.

There were no significant effects from the type of explosive training aid on K-9 team P_d (see Appendix D, Table D-9). This finding must be viewed with concern since is counter intuitive to believe that dogs can find nonvolatile explosives as easily as volatile explosives. There is reason to believe that explosive training aid cross-contamination may have occurred. Cross-contamination refers to the possibility of explosive training aid volatile signatures being combined across other training aids. Improper shipping, storage, and handing techniques increase the likelihood of cross-contamination. It is possible, then, that dogs are detecting aids with only one common volatile signature.

4. ASSESSMENT OF FAA K-9 PROGRAM.

The FAA K-9 Program specifies thorough training for dogs and handlers, and requires that K-9 teams successfully complete an intense certification process. The following sections provide an assessment of initial training, operational maintenance training, and annual certification. Recommendations and issues for future research are provided in Section 6.

4.1 Assessment Of Initial Training - Subsystem 1.

Procurement and initial training were observed at the 341st MWDTS in Lackland AFB.

4.1.1 Procurement.

The procurement function is effective in selecting dogs to receive initial training. The breed of dog selected by the FAA is currently restricted to Labradors, although German Shepherds and Belgian Malanois are in use too. The olfactory capability of Labradors compared to other breeds is unknown. Currently, there is only fragmentary research to indicate that some breeds are better at detecting explosives than others. Differences may well be based more on behavioral and temperamental factors than on differences in olfactory sensitivity as such (e.g. Moulton, 1981). The FAA employs Labradors as K-9 team dogs because of their reputation as being good sniffer dogs, their willingness to please their owner, and because they do not possess threatening features. There is no strong reason to believe that other dog breeds would display significantly superior performance to the Labradors. As noted, the current data showed no significant differences between dog breeds on detection probability.

As for sex, both male and female dogs are used in the program, although the dogs are neutered to reduce hormone-related behavioral changes. The 341st MWDTS indicated that there were no gender differences in the ability of dogs to detect explosives. There is no empirical evidence for or against this opinion, although the MWDTS obviously has a large experience base to draw upon.

4.1.2 Initial Training.

The K-9 Program treats dogs as individuals (within predetermined limits), recognizing that dogs learn at different rates. While the 341st MWDTS provides generally effective explosives detection training, the FAA dogs do not receive much variety in training. Although the FAA's philosophy explains why dogs do not receive dual purpose training, there are theoretical grounds as well as anecdotal evidence from other programs (e.g. the US Secret Service) to believe that dogs which receive training on more than one task experience benefits such as increased working confidence and problem solving skills, improved agility, and improved dog/handler bond.

Previously, the 341st MWDTS trained FAA dogs to be dual purpose (patrol/explosive). The dogs were certified annually as explosive dogs. There was no annual certification in "patrol" certifications. The FAA interpreted this as a potential legal problem because as FAA funded patrol dogs, trained to attack in a crisis situation, they may bite someone in the airport.

The division of the training program into dog and handler training sections is sound. Dogs receive explosive identification training, while handlers receive both patrol training and explosives respond to different situations and fosters the development of handler skills, which continue to teaching search techniques and protocol.

The 341st MWDTS does not train dogs with distracting stimuli present (e.g., peanuts that have fallen to the floor of an aircraft). They instruct handlers to pay attention to their dogs, notice when the dog is curious about novel odors, and then compare that behavior to when the dog is actively seeking explosive odors. Training with distractions, however, can demonstrate that the dog is alert and able to attend to the task within a typical search environment. Problems only arise when the dog does not detect explosives or when it fixates on distractions.

The FAA has not implemented a uniform handler selection process. As such, the selection criteria for handlers vary from city to city. Lack of selection criteria for handlers leaves the FAA K-9 Program vulnerable to training individuals who are not qualified to handle dogs and to resources being expended unnecessarily. Individuals may be physically unqualified or possess personalities that are incompatible with the K-9 Program. Data on handler washout should be collected so that its impact on the program can be assessed. Important aspects to record would be the frequency of handler washout during training, the point in the training cycle where problems were first noted, the point in the program where the trainee washed out, and the basis for the training failure.

4.1.3 Distribution.

This function was not observed during the site visits, but, based on the experience of 341st MWDTS trainers, seemed effective.

4.2 Assessment Of Operational Training - Subsystem 2.

Operational training was observed at Pittsburgh International Airport, Pennsylvania.

4.2.1 Familiarization and Initial Certification.

The 60-day familiarization period and 14-day training mission was not observed, but seems to be an effective process when the procedures are followed. However, results of interviews with the 341st MWDTS and the Pittsburgh K-9 unit suggest that the actual time span depends on scheduling, available city funds, and the overall commitment of the participating city. If a dog is not familiar with or comfortable in an area because of distractions (e.g., noises, food, people), the dog will probably not perform the task of locating explosives until properly acclimated.

4.2.2 Maintenance Training.

The training areas observed in Pittsburgh included a warehouse and an aircraft. While the training scenarios are conducted in operational areas, it was clear that the teams did not meet the environmental conditions of real-world searches. Aircraft searches, for example, were conducted on clean aircraft. Thus, dogs were not exposed to distracting stimuli. The 341st MWDTS indicated that the majority of the participating cities conduct training in clean environments. K-9

units that train in clean environments may become distracted during real searches when areas are cluttered with food, trash, or other objects.

Other problems also exist within this phase of the FAA's K-9 Program. The agencies volunteering to maintain the dogs are sometimes ill equipped or under funded. This may affect the quality of the recurrent training provided to field teams. According to the 341st MWDTS, one problem K-9 teams typically encounter with operational training is access to the required training areas. While access to training areas did not seem to be a major problem for the Pittsburgh K-9 unit, other cities may not provide K-9 teams with sufficient access to training areas. Without access, the K-9 teams cannot meet the 4-hour per week training requirement. The 341st MWDTS indicated that because the FAA K-9 program is voluntary, they cannot mandate cities to provide access to training areas nor mandate the amount of training time. Any successful training program, however, needs support from management to provide the resources for effective training.

Some cities do not have an adequate number of personnel experienced in training K-9 teams. During the operational training site visit, only one handler had such experience. According to the 341st MWDTS, individuals without sufficient expertise in explosives detection or training are often required to act as training instructors. Inexperienced instructors are often unable to provide direction in team behavior, search strategies, or decision making. Personnel experienced in explosives detection training are generally members of a K-9 team already. As seen in Pittsburgh, those individuals often work overtime to train less experienced K-9 teams.

4.3 Assessment Of Annual Certification - Subsystem 3.

The certification of two dog-handler teams was observed at Tulsa, Oklahoma. Reevaluations were not observed.

4.3.1 Evaluation and Reevaluation.

There are no clearly defined procedures for conducting the certifications. Without a well-defined set of procedures, it is possible that different evaluators may be conducting evaluations of different levels of difficulty. The 341st MWDTS evaluators at Tulsa distributed the nine training aids and varied the amount of explosive materials and their location (depth and height), depending on the performance of the dog and other environmental factors (e.g., noise, temperature, air circulation). They indicated that evaluators should use similar procedures for all evaluations, but that planting explosives is very dependent upon environmental conditions.

Insuring the consistency of evaluations for certification is important because it makes it possible to learn fairly quickly when a city is having a problem. If evaluation procedures vary from city to city, then conclusions cannot be drawn from differing results or even similar results. Unfortunately, it is not clear how robust the K-9 training program is to procedural differences in training or evaluation situations. Variations in search locations or even difficulty, as long as they are random from year to year, basically mirror the actual search environment. Problems would arise if such searches were consistently tailored in a particular way. Perhaps the best practice is simply to make sure that locations and difficulty levels are varied within a site and from year to

year. As long as these variations are random, then they can be discounted in city to city comparisons, particularly with results combined over several years.

Leaving aside the question of the assessment of explosives search proficiency, other aspects of the assessment/certification process deserve a close look. For example, according to the 341st MWDTS, evaluations are typically conducted late at night so that the test areas are free from distractions (e.g., people, machinery). As observed in Tulsa, Oklahoma, teams can experience problems with the evaluations if they typically work a day or evening shift, and are tested late at night or in the early morning hours. One argument for conducting late evaluations is that real threat searches could need to be performed during late hours. However, the 341st MWDTS indicated that they want K-9 teams to be optimally ready for the evaluations. If the teams cannot perform under favorable conditions, then it is easy to tell that a serious performance problem exists. Otherwise, more data would have to be collected to make sure that poor performance wasn't an isolated event or due to particularly bad circumstances. Late hour testing also can disrupt a handler or dog's circadian rhythm.

The importance of the evaluation/certification process cannot be overemphasized. Realistically, it is difficult to monitor and control all aspects of such a dispersed and time consuming training program. The surest way to prevent a small problem from unknowingly growing larger is a reliable and valid evaluation process . This provides feedback to evaluators and participants alike on the adequacy of their efforts. The certification process should never be viewed as punishment and given the voluntary nature of much of the participants' activities, it would be futile to use it in that way. However, factors which undermine the accuracy of the evaluation will inevitably lead to program drift or worse (cf. section 4.4). Standardize evaluation procedures whenever possible and when it isn't, then randomize the variations.

4.4 Assessment Of Explosive Materials Handling.

The nine explosive training aids have been selected by U.S. military K-9 units. The 341st MWDTS indicated that since the FAA is a user of the military school and receives dogs trained by the military, that those are the odors the dogs must learn to detect. The use of these explosives is sound as long as they represent the explosive threats used by terrorists.

A potential problem identified during operational training and certification is the issue of cross-contamination. Cross-contamination occurs when odorants are combined across explosive training aids. Cross-contamination can affect the quality of training because highly odorous explosive training aids can mask odors of other explosive training aids. Age, storage, and handling also can affect the likelihood of cross-contamination.

The 341st MWDTS and operational K-9 teams may not adequately consider cross-contamination problems. The local explosive training aid storage facilities were not observed. However, what was observed during the evaluations was that the 341st MWDTS carried all explosive training aids in the trunk of a car. The training aids were packed in containers, but the containers were packed tightly together, possibly allowing the volatile vapors to combine across explosive training aids. It is possible that the explosive training aids were contaminated from the beginning and that the dogs only detected the strongest volatile odor.

The 341st MWDTS does not provide thorough training on handling explosives during the initial explosives detection training (i.e., Subsystem 1). Handlers and evaluators are instructed to wear gloves when handling the explosives. However, it was observed during the operational site visits that personnel at the 341st MWDTS and operational sites often handled different explosives without changing gloves. While the human scent contamination may be minimized, a problem with the combined explosive training aid odors may exist.

The 341st MWDTS recommends that the aids be renewed every 4 months. This generally does not happen, which may cause substantial problems for the dog even though they are capable of detecting very small quantities of explosives.

5. PROJECT SUMMARY.

The FAA's K-9 Program was evaluated to provide the FAA with feedback on the training of operational K-9 teams for explosive threats. Handlers, associated personnel, and FAA evaluators provided valuable information regarding their participation in the FAA K-9 Program. Their willingness to cooperate suggests that the people involved with the FAA explosives detection dog training program believe in its value and want to see it continue.

This report presented the results of an analysis on initial training, operational training, and annual certifications. The following sections summarize issues deserving attention observed with the K-9 Program.

5.1 Initial Training - Subsystem 1.

a. Dogs only receive explosives detection task training (i.e., single purpose training). Dogs should be trained on more than one task to increase working confidence, problem solving skills, agility, and dog/handler bond. It is not necessary that these other tasks be a formal part of the team's duties once on-the-job (i.e., patrol/explosive trained).

b. Dogs are not trained to attend with distracting stimuli present. Given that distractors are inevitable in the real search environment, it would seem prudent to try to arrange at least some similar situations during training. Many research studies have shown that performance is best when the conditions during learning are highly similar to the conditions at test.

c. The FAA K-9 Program is essentially a volunteer program. As such, there are no handler selection criteria to control the required characteristics of handlers, which leaves the program vulnerable to training individuals who are not qualified to handle dogs. The data on trainee washouts described above constitute a good first step in determining the nature and extent of the problem. If it turns out to be significant, some more formal methods of selection should be instituted (e.g. structured interview).

5.2 Operational Training - Subsystem 2.

a. The amount of time the cities spend on maintenance training is dependent upon available city funds. This may affect the quality of the recurrent training provided to the field teams and the overall effectiveness of the K-9 units.

b. Some agencies do not have enough personnel experienced in training K-9 units to detect explosives. The result is that some K-9 team members may have to work on their own time to train less experienced K-9 teams.

5.3 Annual Certification - Subsystem 3.

a. Evaluations are typically conducted late at night, so that the testing areas are free from distractions such as people or machinery. However, late hour testing can disrupt a handler or dog's circadian rhythm. Therefore, testing conducted during late hours may be putting K-9 teams in less than optimal conditions.

b. It was apparent that there are no clearly defined procedures for conducting the certifications. The experience of the evaluators and the testing conditions determine where explosive training aids will be hidden. Further, while a given evaluator may use similar procedures for all evaluations, the procedures may vary across 341st MWDTS evaluator teams.

5.4 Explosive Materials Handling.

Cross-contamination of explosives may occur from improper handling, storage, or shipping techniques. Cross-contamination may affect the quality of training and the validity of assessments because the scents from highly odorous explosive training aids can affect or mask odors from other explosive training aids.

6. RECOMMENDATIONS AND FUTURE RESEARCH.

Recommendations for future research to strengthen the current program and to address the problems described in this document are provided below:

a. The FAA should determine individual attributes of the handlers that are necessary to perform effectively in a detection team. One critical consideration that is missing from the current program is a determination of handlers' knowledge, skill, and abilities (KSAs) required to perform effectively in the detection team. According to Goldstein (1986), task requirements must be translated into the KSAs necessary to perform those tasks. A person analysis would identify the necessary attributes and oblige individuals to demonstrate the KSAs required for the job. The 341st MWDTS indicated that some individuals may perform poorly in training because they were either ill-prepared to enter the program or did not want to learn. A standardized selection process would help identify handlers who are most qualified.

b. The FAA should develop a training troubleshooting guide to assist K-9 teams in resolving commonly encountered training and work problems. Information for the guide would be gathered by surveying experienced handlers and FAA trainers. Maintenance training and honing the skills of the dog and handler would begin immediately after initial training. A properly indexed guidebook that details problem behavior and effective solutions would be an invaluable aid to experienced and inexperienced handlers. It is also recommended that the FAA provide handlers with problem solving strategies, rather than simply training them in search techniques. Problem solving is a cognitive process required by handlers to determine probable areas of explosive threats. Problem solving occurs most effectively when an individual has developed a mental model of the search areas and search pattern. Training in problem solving strategies would assist handlers in developing more efficient strategies and in estimating probable areas that could hide a threat.

c. The FAA should establish a more formal training auditing program to ensure that handlers are not learning and teaching incorrect procedures. Once a dog learns an odor and elicits the proper detection response, it is essential to maintain the detection behavior of the dogs through rehearsal (i.e., operational maintenance training). The FAA should more closely monitor the amount of training that the K-9 teams receive. The 341st MWDTS indicated that even though the FAA requires at least 4 hours of training time per week, some cities fail to provide the proper amount of maintenance training. Without rehearsal in detecting explosives, the dogs will forget the explosive odors and fail to exhibit the proper detection responses.

d. The FAA should regulate procedures for handling and storing explosive training aids. Perceptual masking of one odor by another has been demonstrated in the rat, humans, and several other species (cf. Laing et al, 1989) and there is every reason to believe that the same can occur with dogs. Rats are able to maintain performance to the target odor under increasing levels of masking odor concentration up to a critical concentration level, at which point performance deteriorates sharply and without warning. The implication for cross-contamination of explosives odors in the dog is not good. There may be no gradual indication of loss of stimulus control by the dog prior to failure. Of course, this assumes that the original target substances have been reliably and differentially acquired during training. If cross contamination and masking occurs during acquisition, then the dog may not acquire the masked odor at all. On-site storage, handling,

and transportation are continuing problems. It is necessary to identify the effects of explosive cross-contamination and improve training in handling and storing the explosives.

e. The FAA should research the capabilities and limitations of dogs as explosives detectors. For instance, determinations of olfactory thresholds for explosives need to be accomplished on representative samples of dogs. This will establish whether or not dogs can reliably detect with low vapor pressures emitted from representative concealed sources. The findings of this research could establish optimal methods of integrating new machine-based technology with current detector dog team technology. These technologies can be complementary and will provide the redundancy necessary to meet airport security requirements (Ternes and Prestrude, 1992).

f. A periodic newsletter should be circulated among the participating agencies to provide an effective media for aiding handlers in developing better search techniques, learning solutions to commonly encountered problems, and making suggestions to improve the K-9 Program.

g. Shipping, storage, and handling procedures for explosives should be standardized to minimize cross contamination issues.

h. With every shipment of new training aids, one or two placebos should be packed with actual explosives. These should be handled and placed like "real" explosives to determine if cross contamination is occurring. The funding that dogs are hitting on placebos would strongly suggest that cross contamination has occurred. A possibility of a placebo could be sticks of modeling clay.

7. REFERENCES.

Adams, G. J. and K. G. Johnson, "Sleep, Work, and the Effects of Shift Work on Drug Detection Dogs," *Applied Animal Behavior*, 1994, *41*, 115–126.

Baron, R. A., *Psychology*, Allyn and Bacon, Boston, MA, 1994.

Brown, E. L. and K. Deffenbacher, *Perception and the Senses*. Oxford University Press, New York, NY, 1979.

Cain, W. S., J. R. Mason, and T. H. Morton, *Use of Animals for Detection of Land Mines and Other Explosives, A Review and Critique of Prospects*. (Report DAAK70-84-K-008) U.S. Army Mobility Research and Development Command, 1986.

Carr-Harris, E. and R. Thal, *Mine, Booby-Trap, Tripwire and Tunnel Detection*, Technical Report No. LWL-CR02B67 and 01B68, U.S. Army Limited War Laboratory, Aberdeen Proving Ground, MD, 1970.

Chao, E. T., *Olfaction in Dogs: A Critical Review*, Department of Psychology, Florida State University, Tallahassee, FL, 1977.

Coghill, J. J., The U.S. Perspective of Aviation Security. *Proceedings of the Conference on Methods of Security Screening*, The Royal Society, London, 1992.

Coile, D. C., (in preparation) Chapter on Olfaction, *Canine Sensory Systems*.

Eastwood, B. Beagles Beg Contraband Foodstuffs, *Dog World*, 1990, *75(8)*, 144-149.

Francis, C. Drug Dogs Go Maritime, *Dog World*, 1990a, *75(9)*, 125.

Francis, C. U.S. Customs Opens Doors to Canine Sniffers, *Dog World*, 1990b, *75(7)*, 62-64.

Goldstein, I. L., *Needs Assessment, Development, and Evaluation*, 2nd ed., Brooks/Cole Publishing Company, Pacific Grove, CA, 1986.

Howell, W. C. and N. J. Cooke, Training the Human Information Processor: A Review of Cognitive Models. In I.L.Goldstein (ed.) *Training and Development in Organizations*, Jossey-Bass Publishers, San Francisco, CA, 1989.

Laing, D.G., Panhuber, H. and Slotnick, B.M. Odor masking in the rat. *Physiology and Behavior*, 1989, *45*, 689-94.

Latham, G. P., Behavior Approaches to the Training and Learning Process. In I.L. Goldstein (ed.) *Training and Development in Organizations*, Jossey-Bass Publishers, San Francisco, CA, 1989.

Lovett, S., Explosives Search Dogs. In S. M. Khan (ed.), *Proceedings of the First International Symposium on Explosive Detection Technology*, FAA Technical Center, Atlantic City International Airport, NJ, 1992.

Marshall, D. A., Blumer, L. and Moulton, D.G. Odor Detection Curves for N-Pentanoic Acid in Dogs and Humans, *Chemical Senses*, 1981, *6*, 445–453.

Moore-Ede, M.C., Sulzman, M.C. and Fuller, C.A. *The Clocks That Time Us: Physiology of the Circadian Timing System*, Harvard University Press, Cambridge, MA, 1982.
Moulton, D.G. *Enhancement of olfactory discrimination.* (Report AFOSR-TR-82-0419) Air Force Office of Scientific Research, Bolling Air Force Base, Wash. D.C. 1981.

Moulton, D. G., Ashton, E. H. and Eayrs, J.T. Studies in Olfactory Acuity - 4, Relative Detectability of N-Aliphatic Acids by the Dog. *Animal Behaviour*, 1960, *8*, 117–123.

Neuhaus, W., Uber die Riechscharfe des Hundes fur Fettsauren, *Zeitschrift fur vergleichlende Physiologie*, 1953, *35*, 527–552.

Newell, A. and Simon, H.A. *Human Problem Solving*, Prentice-Hall, Englewood Cliffs, NJ, 1972.

Nolan, R. V. and Gravitte, D.L. *Mine Detecting Canines.* (Report No. 2217) U.S. Army Mobility Equipment Research and Development Command, Ft. Belvoir, VA. 1977.

Passe, D. H. and J. C. Walker, Odor Psychophysics in Vertebrates, *Neuroscience and Biobehavioral Reviews*, 1985, *9*, 431–467.

Prestrude, A. M. and Ternes, J.W. Optimizing Substance Detection by Integration of Canine/Human Team with Machine Technology. In J. L. Flanagan, et al. (eds.), *Proceedings of the Conference on Substance Identification Analytics.* The International Society for Optical Engineering, Bellingham, WA, 1992 .

Pryor, K., *Don't Shoot the Dog*! Bantam Books, New York, NY, 1984.

Sanders, M. S. and McCormick, E.J. *Human Factors in Engineering and Design*, 6th ed., McGraw-Hill Book Company, New York, NY, 1987.

Sternberg, R. J., *In Search of the Human Mind*, Harcourt Brace, Fort Worth, TX, 1995.

Syrotuck, W. G., *Scent and the Scenting Dog.* Arner Publications, Inc., Clark Mills, NY, 1972.

Ternes, J. W. and Prestrude, A.M. Integration of the Human, Canine, Machine Interface for Explosives Detection. In S. M. Khan (ed.), *Proceedings of the First International Symposium on Explosive Detection Technology*, FAA Technical Center, Atlantic City International Airport, NJ, 1992.

Tucker, D. and Smith, D.C. Vertebrate Olfaction. In B. Masterton, et al(eds.), *Evolution of Brain and Behavior of Vertebrates*. Erlbaum Associates, Potomac, MD 1976.

Travis, B. E. and Willett, A. *The Dog Report*, Federal Aviation Administration, Burlington, MA, 1991.

Wright, K., The Sniff of Legend, *Discover*, 1994, *15*(4), 60–67.

Yeaple, J., The Bomb Catchers, *Popular Science*, 1991, *239*(4), 61–104.

APPENDIX A - PROCUREMENT TASK ANALYSIS

TASK ANALYSIS

ACTIVITY: Procurement

ASSUMPTIONS: Choke chain and leash placed on dog, handler out of sight of dog, testing conducted in open grassy field.

Task	Purpose	Cue	Decision	Action	Feedback	Potential Errors
1.0 Select Primary Reward	Determine the dog's primary reward.	Rubber ball and kong ball.	Introduce ball/kong ball to dog.	Bounce the ball/kong ball. Toss the ball/kong ball from hand to hand.	Dog gets excited when introduced to the ball/kong ball. Dog shows no interest in the ball/ kong ball.	Handler does not introduce both ball and kong ball to the dog. Handler makes biased decision as to which reward the dog prefers.
1.1 Near Throw	Further assess the reward value of the ball and kong ball.	Rubber ball and kong ball.	Throw the ball/kong ball to see if the dog will retrieve the reward.	Throw the ball/kong ball about 10 to 15 feet and allow the dog to immediately chase the reward. Handler keeps grip on the leash.	Dog runs and shows eagerness of ball or kong ball. Dog does not run after ball/kong ball.	Handler does not run with dog and dog gets choked by chain.
1.2 Far Throw	Further assess the reward value of the ball and kong ball.	Scented ball/kong ball with theobroma (cocoa butter).	Throw the ball/kong ball to see if the dog will retrieve the reward.	Throw the ball/kong ball 30 to 40 feet and wait 1 minute. Do not keep dog in heel position, but keep it controlled.	Dog is in controlled position and is eager to search for ball/kong ball. Dog uninterested in searching for ball/kong ball.	Handler does not throw properly scented ball or wait 1-minute prior to search.
1.2.1 Far Throw Search	Assess dog olfactory senses.	Scented ball/kong ball with theobroma (cocoa butter).	Search for the ball/kong ball with dog.	Begin searching for the ball/kong ball. Do not talk to the dog. Only assist the dog as a last resort.	Dog begins search and locates area where the ball first hit the ground. Dog finds source. Dog can not find source and looses interest in search.	Handler interferes with the search and locates the ball/kong ball for the dog.
1.3 Tug of War	Further assess the reward value of the ball/kong ball.	Ball or kong ball.	Play tug of war.	Give ball/kong ball to the dog. Grab ball/kong ball with one hand and pull. Always let the dog win.	Dog won't let go of ball/ kong ball and enjoys tug of war (tail wags, dog stays w/handler). Dog not interested in tug of war.	Handler pulls too hard on the reward and injures the dog.
1.4 Food Reward	Same as 1.1. Note: Dog must be deprived of food for 24 hours.	Ken-L-Ration Special Cuts.	Same as 1.1.	Toss food to the dog.	Dog eats food, salivates heavily, body trembles and twitches, eyes bulge. Dog jumps towards handler for more food.	Dog not food deprived. Ken-L-Ration food not used. Food not fresh.

APPENDIX A - PROCUREMENT TASK ANALYSIS
(Continued)

TASK ANALYSIS ACTIVITY: Procurement ASSUMPTIONS: Choke chain and leash placed on dog, handler out of sight of dog, testing conducted in open grassy field.

Task	Purpose	Cue	Decision	Action	Feedback	Potential Errors
1.4.1 Throw Food	Same as 1.1.	Ken-L-Ration Special Cuts.	Same as 1.1.	Same as 1.1.	Same as 1.1.	Same as 1.1.
1.5 Decision time	Decide what stimuli to use as the primary reward.	Ball/kong ball/food.	Determine preference of all three stimuli.	Throw the ball towards a package of food.	Dog drops the ball/kong ball and shows a preference for food. Dog keeps ball firmly in mouth.	Handler makes decision based on personal preference.
1.6 Operational Distractions	Determine the dog's reaction to operational distractions.	Dog has reacted to primary reward.	Expose dog to operational areas. Walk dog on slick floor, carpeted area, rest rooms, store rooms, stairwells.	Expose dog to the area a sufficient number of times or periods to ensure that the dog does not make an aversive response to the area or objects in the area.	Dog adapts to areas and is not hesitant about entering and working in areas.	Dog not exposed to areas a sufficient number of times.
1.6.1 Operational Search	Further evaluate the dog's olfactory capabilities.	Dog not distracted by environmental conditions.	Hide primary reward in various locations within the operational areas.	Place ball/kong ball/food in areas.	Dog detects the primary reward. Dog fails to detect the primary reward.	Dog not tested with the primary reward. Dog not exposed to area a sufficient number of times and is distracted by conditions.
1.7 Medical Exam	Detect any physical limitations of the dog.	Next step of the procurement process.	Conduct appropriate medical tests.	Actions required for specific tests are conducted by Lackland veterinarian staff.	Results of the medical exam.	Dog not examined with appropriate medical tests. Veterinarian does not correctly evaluate the dog.

APPENDIX B - 4-HOLE SCENT BOX PROTOCOL AND TASK ANALYSIS

4-Hole Scent Box Training Protocol.

The 341st Military Working Dog Training School (MWDTS) trains dogs to detect explosives using the scent box protocol and open area training. The dogs are trained to detect nine explosive training aids. Once the dog successfully detects the explosive training aids hidden in the scent box, the 341st MWDTS trains dogs to detect the same explosive scent in open areas.

The 341st MWDTS administers the 4-hole scent box protocol. Dogs are given 10 days to meet the criterion as described below.

4-Hole Scent Box.

The 4-hole scent box training is conducted with every dog. Figure B-1 shows an example of a scent box. The protocol requires that four scent boxes be set on the floor with 3-foot separations. One of the boxes contains an explosive training aid, while the remaining three boxes remain empty. Each trial uses four boxes, but with an explosive training aid hidden in only one box. Dogs start in the sit position, 3 feet away from the first box (see Figures B-2 and B-3). Handlers present the box to the dog ensuring that it sniffs in or above the hole (see Figure B-4). The dog is provided time to respond before proceeding to a subsequent box. If the dog exhibits a correct sit response, the handlers present primary, then secondary rewards (see Figures B-5 and B-6). If the dog exhibits an incorrect sit response, the handler pulls the dog out of the response position and continues to the next box.

Dogs must successfully accomplish seven steps for each explosive training aid (see Figure B-7). Each step presents an explosive training aid hidden in a different scent box. Beginning with the first box, the dog must successfully detect the training aid five consecutive times unassisted. At this time, the box with the odor is moved to the second position. The handler presents the first box to the dog, but should try to keep the dog from sitting, and then presents the second box. This is repeated until the dog achieves five consecutive detection responses at the second box. After the second whole sequence, the positions are randomized between box one and box two, until the dog meets the criterion of five consecutive trials. Then the training aid is placed in position (box) three for a criterion of five, then randomized between one, two, and three. This sequence is done until all four boxes are completed. Finally, dogs must meet a criterion of 15 consecutive trials randomized in each of the four boxes.

Figure B-1 provides an illustration of the 4-hole scent box training protocol. As shown, there are seven sequential steps that a dog must successfully accomplish to meet criteria on any one odor. This must be accomplished before the dog can be advanced to the next odor.

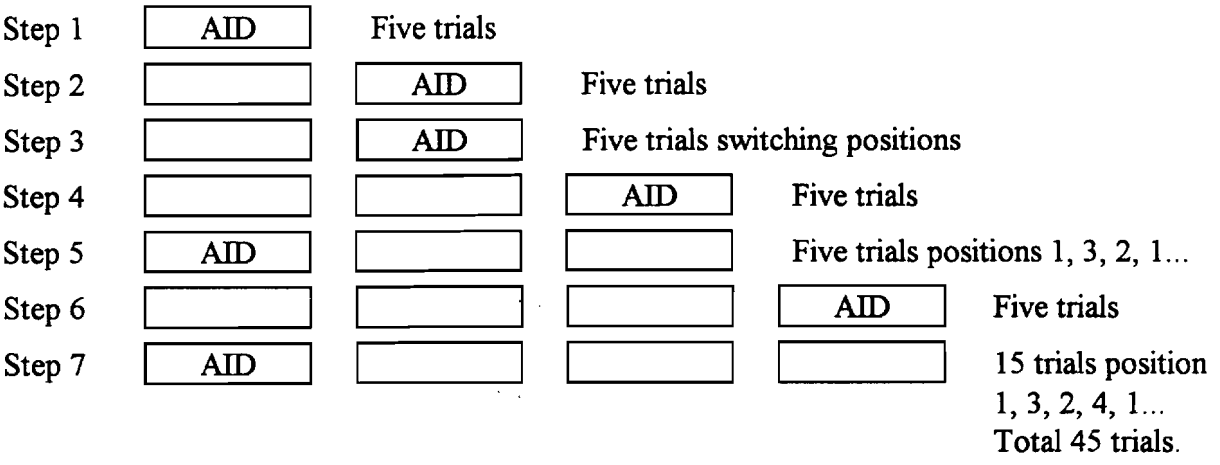


FIGURE B-1. ILLUSTRATION OF 4-HOLE SCENT BOX PROTOCOL

Open Area.

Open area training was not observed during the site visits. Information was gathered from interviews with the 341st MWDTS and from the 341st MWDTS Detector Dog Owner's Manual (1991). The 341st MWDTS provides open area training when a dog attains the first 4-hole scent box criterion level for a given training aid. Open area training can be conducted in any area that is not used for the annual certification. Environments such as open fields, parking lots, and indoor rooms are often used for open area training. Dogs are trained to detect training aids at increased search distances and at different heights above ground level with variable concentration levels of the training aids. As dogs demonstrate proficiency on a training aid, the search distance is increased in 6-foot increments. This teaches the dogs to search for the training aid and provide a sit response at its exact location. The number of explosive training aids is increased and gradually hidden in a variety of locations similar to those in an operational airport.

The 341st MWDTS indicated that there are no criteria for open area training; rather, proficiency is evaluated in terms of the 341st MWDTS's experience. As the dog becomes proficient in detecting a training aid, the daily number of trials can be reduced on that explosive training aid.

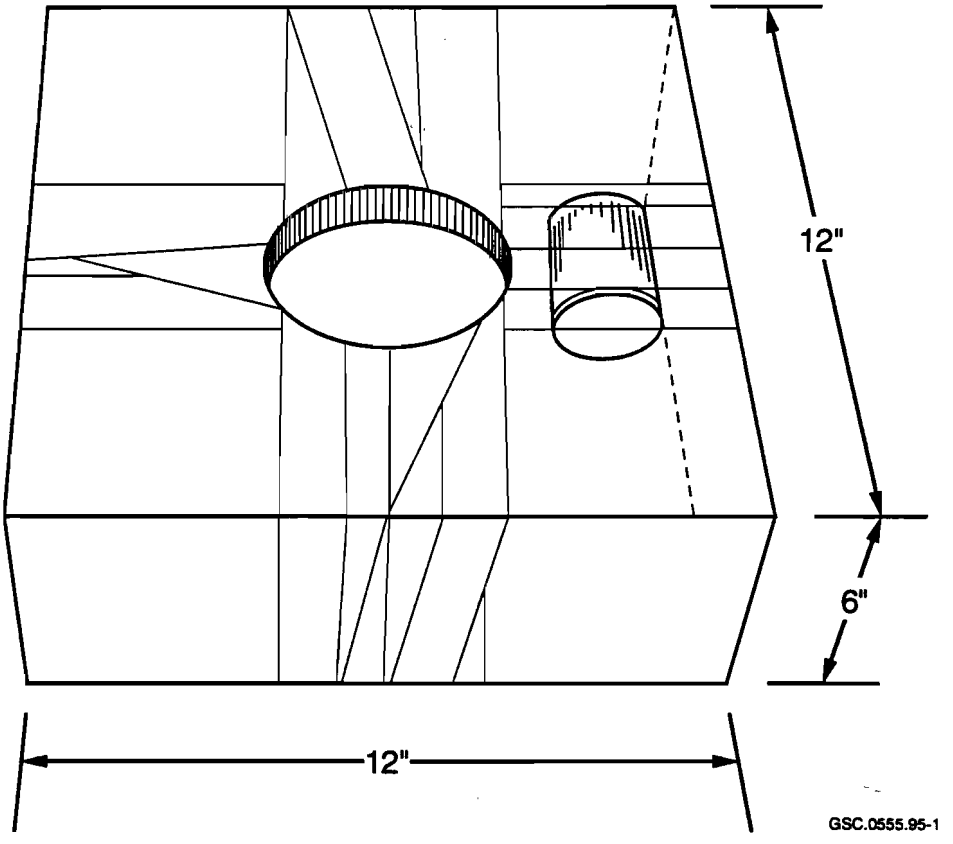


FIGURE B-2. SCENT BOX

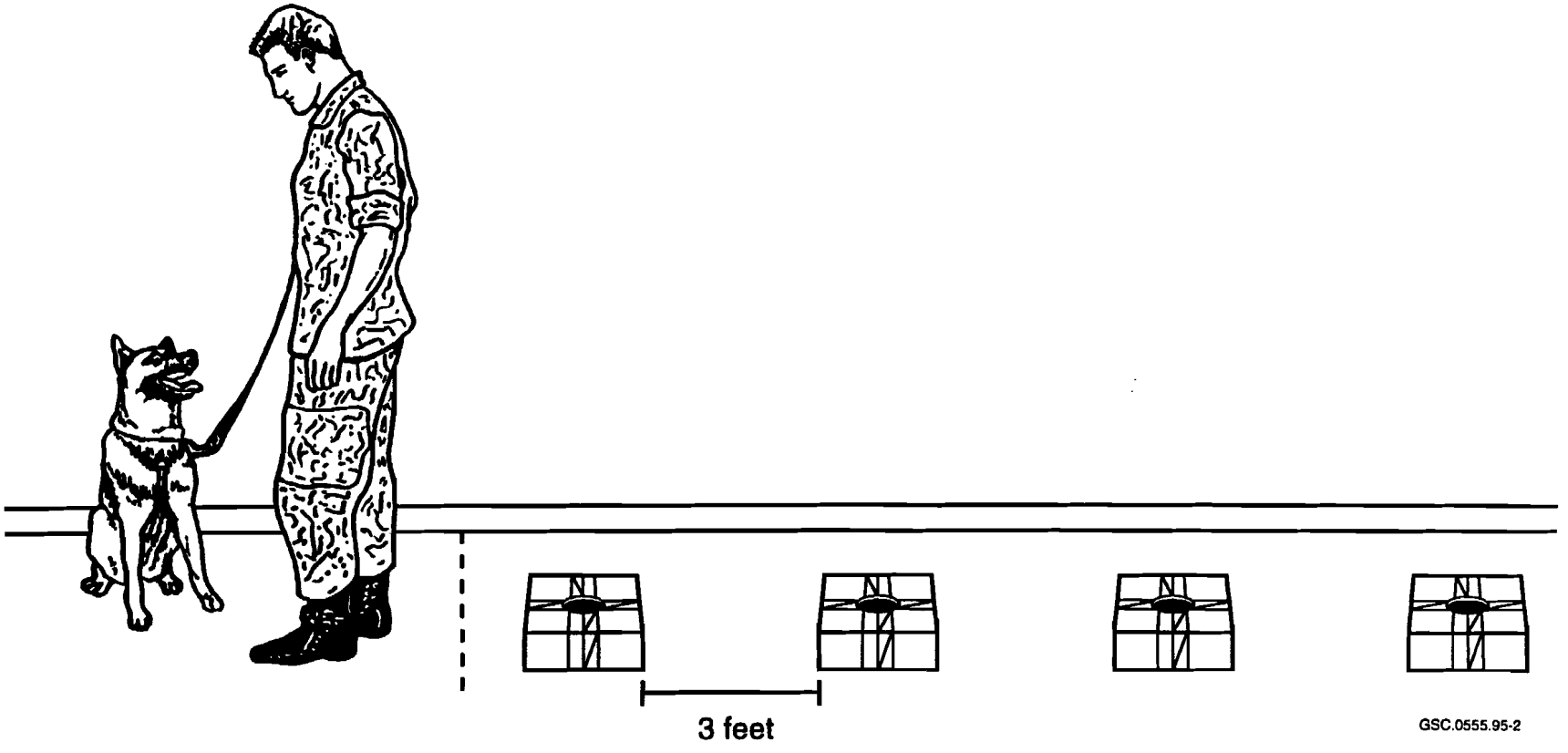


FIGURE B-3. 4-SCENT BOX ARRANGEMENT

FIGURE B-4. DOG PREPARES TO BEGIN 4-SCENT BOX PROTOCOL

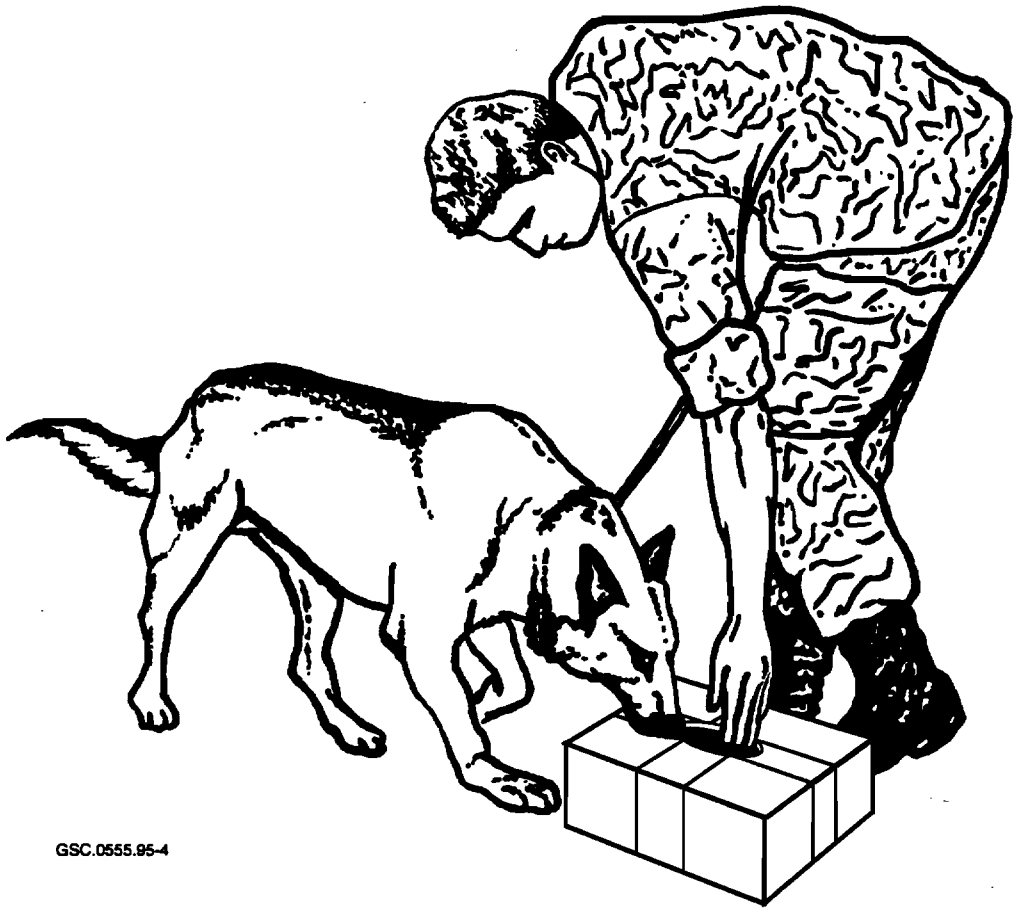
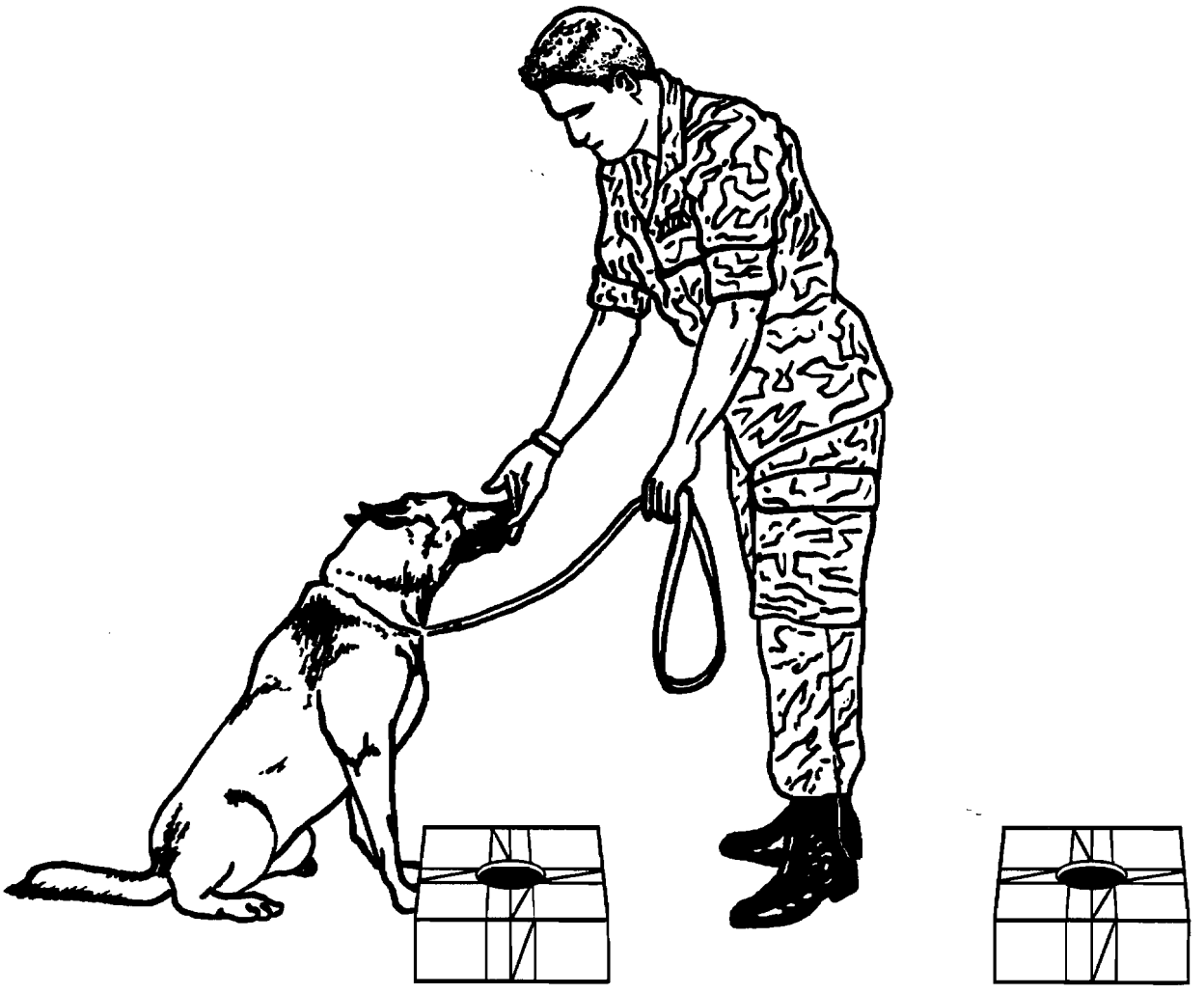


FIGURE B-5. DOG SNIFFS SCENT BOX FOR TARGET ODOR

FIGURE B-6: DOG DETECTS TARGET ODOR AND PROVIDES SIT RESPONSE



GSC.0555.95-6

FIGURE B-7. HANDLER PROVIDES PRIMARY REWARD TO DOG FOR CORRECTLY DETECTING TARGET ODOR

Table B-1 provides a task analysis of the 4-hole scent box training, with the assumptions that appropriate explosives have been hidden in the scent box, and that the scent boxes are arranged in proper sequence.

TABLE B-1. TASK ANALYSIS OF 4-HOLE SCENT BOX TRAINING

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
1.0 Begin Scent Box training	Train dog to detect explosives.	Four scent boxes arranged in one row. Scent boxes are 12" x 12" x 6" in size and have a 4" hole cut in the top center. Box is marked with odor it contains.	Begin search.	Start dog in sit position, 3 feet from first box. Lead dog to scent box with verbal command "seek." Dog places his nose in hole in top of first scent box.	Dog sits or continues to next scent box.	Dog provides false response, fringe response. Handler does not recognize dog in sit position.
1.0.1 Reward Dog	Dog detects explosive. Reinforce search detection behavior.	Dog sits next to scent box with training aid.	Provide dog with primary reward.	Handler instructs dog to "sit and stay." Handler provides dog with primary reward.	Dog takes primary reward from handler and handler pets dog.	Handler does not provide primary reward to dog after sit response. Handler provides primary reward for incorrect sit response.
1.0.2 Pull Dog from Sit Response	Dog incorrectly responds. Continue search.	Dog sits next to scent box.	Do not provide dog with food reward.	Continue to next scent box in search pattern.	Provide dog with seek command and continue searching boxes.	Handler pulls dog out of correct sit response.
1.1 Continue Search	Detect training aid in scent box.	Next scent box in the pattern.	Detect training aid.	Continue search until all scent boxes have been thoroughly searched.	Same as 1.0.	Same as 1.0.
1.2 Continue Training	Continue with training.	Dog has correctly detected an explosive.	Arrange training aid in appropriate box sequence and begin new trial.	Same as 1.0.	Same as 1.0.	Same as 1.0.
1.3 Terminate Search	All scent boxes have been thoroughly searched; search complete.	Team has searched all boxes. Dog meets criteria and is proficient in detecting aid.	Change aid or give dog a rest.	Handler plays with dog while 341st MWDTS arranges boxes and dog returns to kennel.	Team stops search.	Team unsuccessful in identifying all explosive threats.

APPENDIX C - OPERATIONAL AND EVALUATION SEARCH TASK ANALYSES

TASK ANALYSIS ACTIVITY: Luggage Search

ASSUMPTIONS: Bags have been prearranged in rows; bags laid flat on ground; handles forward; explosives hidden in bags

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
1.0 Search Preparation	Team assesses new environment to determine best method of search.	Arrangement and number of bags; environmental conditions.	Starting point and searching pattern.	Assess size of search area, number of bags, air current, bag configuration, environmental conditions, dog status.	Team performs necessary actions and positions in front of first bag ready to begin search.	Team does not fully assess environment and search pattern; dog is not comfortable with situation; handler cannot control dog.
1.1 Begin Luggage Search	Locate explosive threat(s) in passenger bags.	Arranged passenger bags.	Begin detection search.	Step toward bag and give dog verbal seek command. Breathe first bag and lead dog across baggage seams. Start on left side of bag.	Bag emits air and dog sniffs seams in a counterclockwise manner; dog sits or continues to search next bag in the row.	Handler does not breathe bag. Dog provides false response, fringe response, aggressive response; handler does not recognize dog sit position.
1.1.1 Reward Dog	Dog detects explosive. Handler reinforces search detection behavior.	Dog sits next to bag.	Provide dog food reward.	Instruct dog to stay, provide dog food treat, handler responds "good dog." Continue search.	Dog takes food reward from handler and handler pets dog.	Handler does not provide reward to dog after sit response. Handler provides food reward for incorrect sit response.
1.1.2 Pull Dog from Sit Response	Dog incorrectly responds. Continue search.	Dog sits next to bag.	Do not provide dog food reward.	Continue to next bag in search pattern.	Provide seek command and continue on search pattern.	Handler pulls dog out of correct sit response.
1.2 Continue Search	Detect explosive threat in passenger bag.	Next bag in the row.	Detect threat.	Continue search until all bags have been thoroughly searched.	Same as 1.1.	Same as 1.1.
1.3 Terminate Search	All bags and areas thoroughly searched; search complete	Team searched all bags, handler pulls dog from search area.	End search and call "terminate search."	Handler verbally calls "terminate search."	Team stops search.	Team unsuccessful in identifying all explosive threats.

APPENDIX C - OPERATIONAL AND EVALUATION SEARCH TASK ANALYSES
(Continued)

TASK ANALYSIS — ACTIVITY: Interior Aircraft Search — ASSUMPTIONS: Aircraft clear of airline and maintenance personnel; explosives hidden in aircraft; dog has been exposed to working distractions; aircraft configured according to airport standard operating procedures.

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
2.0 Search Preparation	Ensure proper interior aircraft conditions.	Aircraft internal ventilation system working; no cross-ventilation.	Turn off internal ventilation system and develop cross-ventilation.	Turn off ventilation system; open cockpit window or front door and rear window; close exterior entrances.	Ventilation system not running, doors open for cross-ventilation.	Handler forgets to set the proper aircraft conditions.
2.1 Interior Assessment	Team assesses environment to determine search method.	Aircraft interior configuration.	Identify areas that may easily conceal explosives.	Visually inspect interior of aircraft for areas that may easily conceal explosive.	Areas appear normal; areas contain objects that appear to be out of place.	Handler forgets to visually inspect interior and does not visually identify objects.
2.2 Begin Aircraft Search	Locate explosive threat(s) in aircraft.	Internal configuration of aircraft.	Begin with front area search, followed by cabin section.	Move to the front of the aircraft.	Team moves to front and prepares for search.	Handler forgets to first search front area.
2.2.1 Front Area Search	Locate explosive threat(s) in aircraft.	Aircraft's front areas (i.e., cockpit, galley, etc.).	Search front areas.	Ensure that areas are safe (i.e., galley area is clear of sharp objects and oven temperature is cool).	Team thoroughly searches area. Dog provides sit response or continues search.	Dog gives false response, fringe response, aggressive response; handler does not recognize dog sit position.
2.2.2 Cabin Search	Complete inspection of cabin section.	Passenger seats and overhead storage compartments.	Search cabin areas.	Start with first row of seats. Dog first smells low areas of seats, next smells overhead areas.	Dog smells areas below seats and behind seats; dog jumps up on seats to smell overhead. Dog provides sit response or team continues search.	Same as 2.1.1.
2.2.3 Reward Dog	Dog detects explosive. Reinforce search detection behavior.	Dog provides sit response.	Provide dog food reward.	Instruct dog to stay, provide dog food treat, handler responds "good dog." Continue search.	Dog takes food reward from handler and handler pets dog. Team continues search.	Handler does not reward dog after sit response. Handler rewards dog for incorrect sit response.
2.2.4 Pull Dog from Sit Response	Dog incorrectly responds. Stop incorrect search detection behavior.	Dog sits next to vehicle.	Do not provide dog food reward.	Continue in search pattern.	Provide seek command and continue on search pattern.	Handler pulls dog out of correct sit response position.
2.3 Terminate Search	All vehicles and areas thoroughly searched; search completed.	Team searched all bags, handler pulls dog from search area.	End search and call "terminate search."	Handler verbally calls "terminate search."	Team stops search.	Team unsuccessful in identifying all explosive threats.

APPENDIX C - OPERATIONAL AND EVALUATION SEARCH TASK ANALYSES
(Continued)

TASK ANALYSIS ACTIVITY: Vehicle Search ASSUMPTIONS: Vehicles have been prearranged in rows; explosives hidden in automobile(s); dog has been previously exposed to natural working distractions

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
3.0 Search Preparation	Team assesses new environment to determine best method of search.	Arrangement and number of vehicles; environmental conditions.	Starting point and searching pattern.	Assess size of search area, number of vehicles, air current, vehicle config-uration, environmental conditions, dog status.	Team performs necessary actions and positions in front of first bag and ready to begin search.	Team does not fully assess environment and search pattern; dog is not comfortable with situation; handler cannot control dog.
3.1 Vehicle Assessment	Protect dog from hot or sharp objects.	Temperature of vehicles; any sharp protrusions.	Alert dog of danger area; skip search of danger area; return to area after danger minimized (i.e., vehicle cooled off, glass swept up).	Conduct search in safe area.	Team begins search in safe area.	Team forgets to return to skipped area.
3.2 Begin Vehicle Search	Locate explosive threat(s) in vehicles.	Arranged vehicles.	Begin detection search.	Step toward vehicle and give dog verbal command "seek."	Search in a counterclockwise manner. Pay particular attention to fenders, wheels, wheel wells, hub caps, bumpers, doors, hood, and truck areas; dog sits or continues to next vehicle.	Dog provides false response, fringe response, aggressive response; handler does not recognize dog sit position.
3.2.1 Reward Dog	Dog detects explosive. Reinforce search detection behavior.	Dog sits next to vehicle.	Provide dog food reward.	Instruct dog to "stay," provide dog food treat, handler responds "good dog." Continue search.	Dog takes food reward from handler and handler pets dog.	Handler does not reward dog after sit response. Handler gives food reward for incorrect sit response.
3.2.2 Pull Dog from Sit Response	Dog incorrectly responds. Stop incorrect search detection behavior.	Dog sits next to vehicle.	Do not provide dog food reward.	Continue to next vehicle in search pattern.	Provide seek command and continue search pattern.	Handler pulls dog out of correct sit response position.
3.3 Terminate Search	All vehicles and areas thoroughly searched; search completed.	Team searched all bags, handler pulls dog from search area.	End search and call "terminate search."	Handler verbally calls "terminate search."	Team stops search.	Team unsuccessful in identifying all explosive threats.

APPENDIX C - OPERATIONAL AND EVALUATION SEARCH TASK ANALYSES
(Continued)

TASK ANALYSIS ACTIVITY: Freight/Warehouse Search ASSUMPTIONS: Warehouse is clear of all airline and maintenance personnel; explosives hidden in warehouse; dog has been previously exposed to natural working distractions

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
4.0 Search Preparation	Team assesses new environment to determine best method of search.	Physical architecture of warehouse; freight within warehouse.	Starting point and searching pattern.	Assess size of search area, number of vehicles, air current, vehicle configuration, dog status, environmental conditions.	Team performs necessary actions and positions in front of first bag and ready to begin search.	Team does not fully assess environment and search pattern; dog is not comfortable with situation; handler cannot control dog.
4.1 Warehouse Assessment	Protect dog from hot or sharp objects	Temperature of vehicles; any sharp protrusions.	Alert dog of danger area; skip search of danger area; return to area after danger minimized (i.e., vehicle cooled, glass swept up).	Conduct search in safe area.	Team begins search in safe area.	Team forgets to return to skipped area.
4.2 Begin Warehouse Search	Locate explosive threat(s) in vehicles.	Arrangement of vehicles.	Begin detection search.	Step toward vehicle and give dog verbal command "seek."	Search in a counterclockwise manner. Pay attention to fenders, wheels, wheel wells, hub caps, bumpers, doors, hood, and truck areas; dog sits or continues to next vehicle.	Dog provides false response, fringe response, aggressive response; handler does not recognize dog sit position.
4.2.1 Reward Dog	Dog detects explosive. Reinforce search detection behavior.	Dog sits next to vehicle.	Provide dog food reward.	Instruct dog to "stay," provide dog food treat, handler responds "good dog." Continue search.	Dog takes food reward from handler and handler pets dog.	Handler does not provide reward to dog after sit response. Handler provides food reward for incorrect sit response.
4.2.2 Pull Dog from Sit Response	Dog responds incorrectly. Stop incorrect search detection behavior.	Dog sits next to vehicle.	Do not provide dog food reward.	Continue to next vehicle in search pattern.	Provide seek command and continue search pattern.	Handler pulls dog out of correct sit response.
4.3 Terminate Search	All vehicles and areas thoroughly searched; search completed.	Team searched all bags, handler pulls dog from search area.	End search and call "terminate search."	Handler verbally calls "terminate search."	Team stops search.	Team unsuccessful in identifying all explosive threats.

TASK ANALYSIS ACTIVITY: Terminal Search ASSUMPTIONS: Warehouse is clear of all airline and maintenance personnel; explosives hidden in warehouse; dog has been previously exposed to natural working distractions

Task	Purpose	Cue	Decision	Action	Feedback	Likely Errors
5.0 Search Preparation	Team assesses new environment to determine best method of search.	Physical architecture of terminal; objects within terminal; numerous areas within terminal.	Starting point and searching pattern.	Assess size of search area, number of areas, air current, objects within areas, environmental conditions, dog status.	Team performs necessary actions and positions in first search area; team ready to begin search.	Team does not fully assess environment and search pattern; dog is not comfortable with situation; handler cannot control dog.
5.1 Begin Terminal Search	Locate explosive threat(s) in terminal.	First area of selected terminal.	Begin explosive search.	Step in area and search in clockwise direction. Inspect entire area and all objects. Pay attention to air currents, ventilation equipment, all other objects and furniture.	Searches in logical manner. Handler uses verbal encouragement to dog, handler points to objects to be searched.	Dog provides false response, fringe response, aggressive response; handler does not recognize dog sit response position.
5.2.1 Reward dog	Dog detects explosive. Reinforce search detection behavior.	Dog sits next to object within area.	Provide dog food reward.	Instruct dog to "stay," provide dog food treat, handler responds "good dog." Continue search.	Dog takes food reward from handler and handler pets dog.	Handler does not provide reward to dog after sit response. Handler provides food reward for incorrect sit response.
5.2.2 Pull dog from sit response	Dog incorrectly responds. Stop incorrect search detection behavior.	Dog sits next to vehicle.	Do not provide dog food reward.	Continue to next area in search pattern.	Provide seek command and continue search pattern.	Handler pulls dog out of correct sit response.
5.3 Terminate search	All areas and objects thoroughly searched; search completed.	Team completed search, handler pulls dog from search area.	End search and call "terminate search."	Handler verbally calls "terminate search."	Team stops search.	Team unsuccessful in identifying all explosive threats.

APPENDIX D - FAA K-9 PROGRAM ANNUAL CERTIFICATION DATA ANALYSIS

TABLE D-1. MEAN CERTIFICATION RATINGS AND STANDARD DEVIATIONS FOR EACH AIRPORT

Airport	Number of Teams	Mean Rating	Standard Deviation
Atlanta	3	96.20	0.00
Birmingham	2	100.00	0.00
Boston	5	95.42	1.74
Charlotte	2	100.00	0.00
Cincinnati	2	82.65*	13.60
Denver	2	96.20	0.00
Dallas-Ft. Worth	4	99.05	1.90
Detroit	4	99.02	1.95
Houston	5	78.40**	24.12
Jacksonville	2	98.10	2.69
Los Angeles	2	96.15	5.44
Orlando	2	100.00	0.00
Memphis	1	92.30	0.00
Miami	5	88.04*	18.54
New Orleans	1	96.20	0.00
Chicago	4	99.02	1.95
Portland	2	92.30	0.00
Pittsburgh	1	70.60*	0.00
San Diego	2	98.10	2.69
Seattle	4	76.60**	30.59
San Francisco	6	96.81	4.48
Puerto Rico	4	91.00	6.76
Salt Lake City	2	90.40	2.69
St. Louis	1	84.00*	0.00
Tulsa	2	96.15	5.44
Tucson	2	94.25	2.76

* One team did not pass annual certification.

** Two teams did not pass annual certification.