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Psychological Deterrents to Nuclear Theft: A Preliminary Literature Review and Bibliography

Patrick G. Meguire
Joel J. Kramer

Center for Consumer Product Technology
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

Prepared by
Law Enforcement Standards Laboratory
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Intelligence and Security Directorate
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U.S. DEPARTMENT OF COMMERCE, Elliot L. Richardson, *Secretary*
James A. Baker, III, *Under Secretary*
Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

ABSTRACT

A review of the unclassified literature dealing with psychological deterrents was conducted for the Defense Nuclear Agency (DNA). Its purpose was to identify techniques that might be useful in DNA's Forced-Entry Deterrent Systems (FEDS) Program for psychologically deterring nuclear weapon theft. The review indicates that while human psychological processes (sensory, perceptual, and cognitive) can be manipulated by various means, definitive empirical data are lacking which directly relate to deterring nuclear weapon theft. Behavioral impact research should be undertaken by DNA to (1) ascertain the deterrence values of the many techniques identified and (2) test the hypotheses implicit in the FEDS concept.

KEYWORDS: Behavioral impact; cognitive processes, nuclear weapon theft; perceptual processes; psychological deterrence; security systems; sensory processes; threat analysis

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Psychological Deterrents to Nuclear Theft: A Preliminary Literature Review and Bibliography

1. INTRODUCTION

In recent years, there has been an increased concern over the possibility that nuclear materials or weapons might be stolen or diverted for purposes of political blackmail and/or terrorism. With this possibility and its grim consequences in mind, responsible government and industrial officials have been voicing concern over the adequacy of contemporary security systems, procedures and nuclear safeguards. Two recent books on the subject, The Curve of Binding Energy by John McPhee [2], and Nuclear Theft: Risks and Safeguards by Mason Willrich and Theodore B. Taylor [4], have dramatically popularized the reality and feasibility of nuclear theft.

While the preponderance of the concern has been directed at physical security considerations such as the strength of barriers, the effectiveness of automatic intrusion detection and alarm systems, and the preparedness of responsible security force teams, there has also been recent interest in the potential application of psychological/behavioral principles to the design of security devices/systems. The incorporation of such principles into hardware design and security system development may result in increasing the likelihood of an attempted theft being aborted once it has begun, primarily through manipulating human sensory, perceptual, and cognitive processes.

The primary purpose of this report is to provide the Defense Nuclear Agency (DNA) with an unclassified literature review and bibliography related to the psychological/behavioral factors that should be considered in the design, development and conceptualization of a new Forced-Entry Deterrent System (FEDS). DNA has defined FEDS to be "a system composed of one or more of several optional security elements, each of which is specifically designed to impact upon the human senses for the purpose of impeding, delaying, diverting or dissuading unauthorized entry, and if gained, seriously impeding an attempt to escape and remain undetected." From a total systems viewpoint, a forced-entry deterrent system should enhance the capabilities of security response forces/personnel.

Since the concept of psychological deterrence to nuclear theft is of recent origin and since the topic of nuclear theft is of a highly sensitive nature, it was nearly impossible to find unclassified behavioral research sources directly relevant to nuclear security. As a result, the research cited in this report is of an extremely diverse nature and is only indirectly related to the psychological deterrence concept. Nevertheless, the review and bibliography provide a good indication of the work which has been conducted to date and may provide some useful guidelines for the planning of DNA's future research, development and evaluation efforts. A search of the classified literature was recently begun by NBS behavioral scientists and, to the extent that this source provides more relevant research results, a separate report will be prepared and submitted in a manner jointly agreed to by NBS and DNA.

It should be noted that while the difference between psychological deterrence and physical deterrence is often of a very subtle nature, the emphasis of this report is upon means of directly affecting the sensory, perceptual, and cognitive processes of potential intruders. Other psychological processes including learning, motivation, and psycho-social, have been examined to a much lesser extent. In general, any means of affecting the performance efficiency and/or motivation of an assault group may be considered to have psychological/behavioral components. Hence, all physical security systems have some psychological deterrence value. Only those studies citing specific behavioral data have been considered.

Nuclear theft might be attempted at any of a wide variety of locations, including atomic power plants, fissionable material processing plants, military installations, and in transit. DNA's mission, and the fact that weapons are in high demand by terrorist organizations, served to limit this report to security considerations in and around military facilities containing one or more Nuclear Weapons Storage Sites (NWSS). The application of FEDS to other potential nuclear theft target areas is not to be excluded, however, as a related and natural outgrowth of the current effort.

Reproductions of all available articles and other sources found useful in preparing this report will be submitted under separate cover as an appendix to this report.

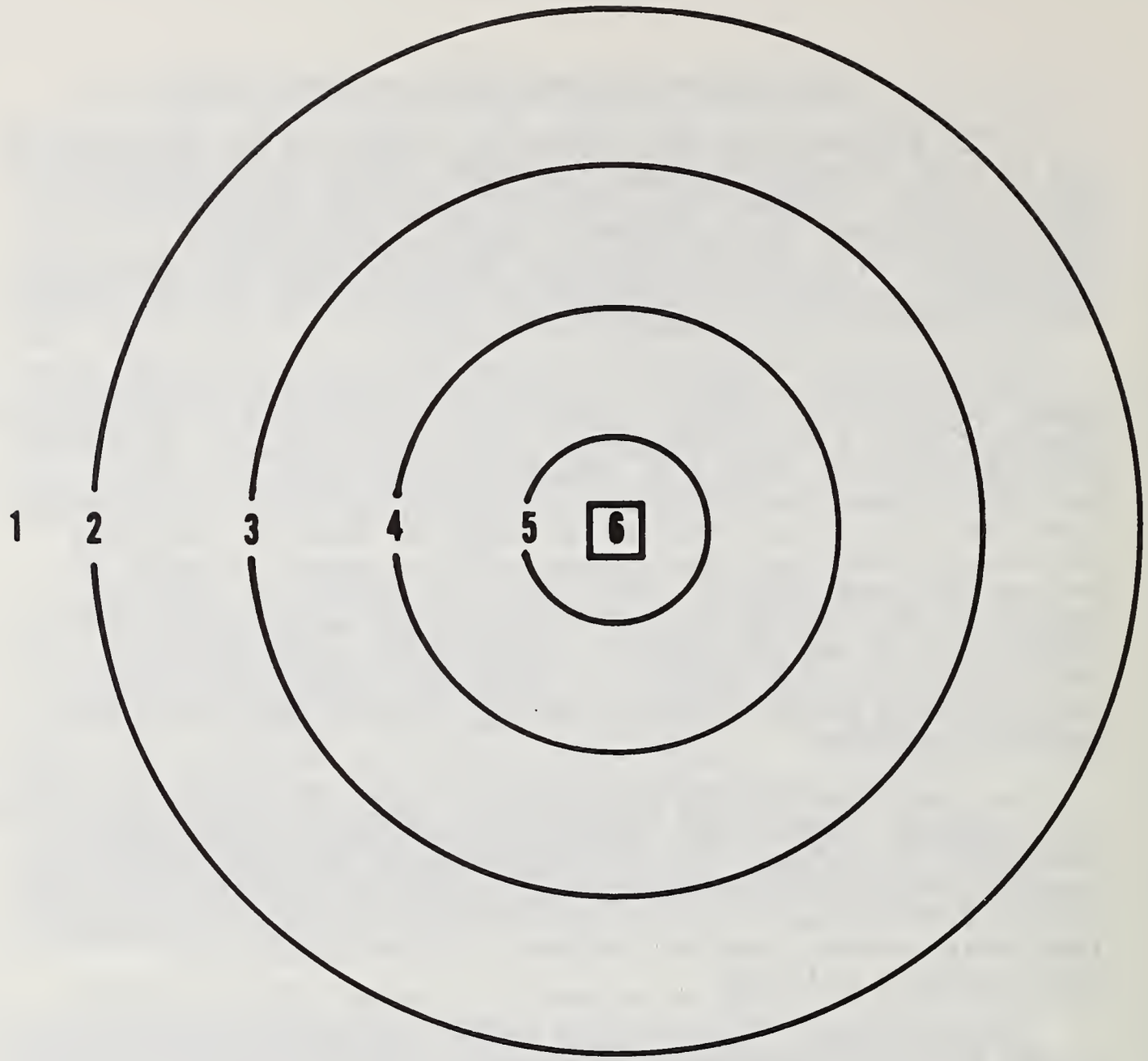
2. The Nuclear Weapons Storage Site (NWSS)

It is assumed that the target of attack by an adversary is one or more portable nuclear warheads stored in a dedicated installation complex, such as a Nuclear Weapons Storage Site. For the purposes of the present report, FEDS design considerations will be limited to the NWSS and its immediate vicinity, although it is recognized that an attack may involve areas outside of the immediate vicinity.

Our conceptual diagram of a nuclear storage facility is shown in figure 1. This diagram is not specific to any storage facility, nor is it a suggestion for layout design. It merely conceptualizes a series or progression of barriers from periphery inward to the target (nuclear device). It suggests that the goal of the FEDS is to delay or halt an intrusion attempt at some specified stage prior to penetration of the Nuclear Weapons Storage Unit (NWSU) or negate an achieved access to the device, e.g., by activating mechanisms which render the device inoperable. The figure represents a progression in time as well as in space since the "rings" function as a delaying action by the FEDS to gain time for defense response.

The functions of the barriers in figure 1 should reflect an increasingly drastic and aggressive defense response from periphery to center. The extra-perimeter area and perimeter barrier should have primarily non-injurious surveillance and delaying functions, i.e., they should be designed to handle low-level threats such as hunters, curious hikers or adventuresome children.

In the center, i.e., in the NWSU, the FEDS may be disabling to the extent of rendering the nuclear device inoperable or of destroying the nuclear device, the attackers and, if absolutely necessary, the defenders. Between the periphery and the center, the level of destructiveness of the barriers must be governed by considerations of effectiveness in deterrence tactics; e.g., disruption of communication or degradation of decision making might be more effective than bodily injury in disrupting the overall effectiveness of intrusion operations.



1. Extra-perimeter area (clear zone)
2. Perimeter barrier
3. Inner barrier
4. Inner barrier
5. Nuclear Weapons Storage Unit(s)
6. Nuclear device(s)

Figure 1. Nuclear Weapons Storage Site

3. THREAT CHARACTERIZATION

There are numerous reasons why one or more persons may attempt an intrusion into or near a NWSS. Similarly, the seriousness and dedication with which an attempt is made may vary widely. With these considerations in mind, intrusion attempts may best be conceptualized as lying upon a threat continuum ranging from a null level threat through a worst-case threat. Typical threats along this continuum might include:

Threat Level	Example
o Null-level threat	No attempted intrusion in progress; most common situation at NWSS.
o Low-level threat	Child intruding to retrieve ball; farmer intruding to retrieve livestock.
o Medium-level threat	Small group of moderately prepared and motivated intruders attempting to vandalize or disrupt operations at NWSS.
o High-level threat	Medium to large size group of highly-trained, dedicated, and well prepared terrorist intruders attempting a full-scale, well-planned, nuclear weapon theft.
o Worst-case threat	Probably equivalent to high level threat with the addition of complete intelligence information and a willingness to die for the cause.

Considering the great diversity of possible threats, physical and psychological intrusion deterrence systems should be designed to deal effectively, yet discriminately, with the entire range of the threat continuum. Hence, the child or thrill seeker attempting an intrusion should ideally be deterred by passive, non-harmful means; while a group representing the worst-case threat must be deterred by any means possible. In general, the greater the threat level, the more efficient the physical and psychological deterrents should be.

If a FEDS is designed to effectively protect against the worst case threat, it is reasonable to assume that lesser threats will also be addressed. However, the measures designed to cover the worst case may be too drastic in the event of a low-level threat. FEDS must therefore effectively deal with this problem, and this is the major reason for the graduated deterrence indicated in the model.

3.1 The Terrorist Threat

The development of nuclear weaponry and associated weapons delivery systems, combined with the astronomic cost of large-scale, conventional warfare, tends to make direct conflict between major powers a highly risky and undesirable endeavor. In recent years, we have continued to see subsidized conflicts between and within relatively small nations. A climate of "controlled conflict" has led to the wide-spread development of small-group combat tactics highly suitable for direct, short-term employment against government facilities and installations.

These specialized, small-group combat tactics are well-suited for the militant arms of small protest, dissident, or grievance groups which utilize terrorism as a political technique. The wide-spread existence and shifting alliances of these groups provide terrorists with world-wide recruiting, training and deployment capabilities. Hence, terrorists might be recruited in one country, trained in another country, and deployed against targets in yet another country. Clearly, few generalizations can be made concerning the cultural and ideological backgrounds of potential terrorist groups.

While terrorists have yet to attempt the theft of a nuclear device, there have been some related incidents which would indicate that the possibility does exist. A student threatened to blow up Orlando, Florida by use of a homemade nuclear weapon, unless given $1 million. A man hijacked an airplane and threatened to dive-bomb the Oak Ridge National Laboratory. High-level U.S. Army sources have stated in a recent Washington Post article that the quantity and variety of weapons stolen from U.S. arms rooms are already sufficient to equip the equivalent of ten full battalions.

The precise number of terrorist groups in existence in the world at present is unknown, but best estimates indicate the existence of at least 50 such groups, most of them well-financed. The seriousness of the terrorist threat has been discussed in a wide variety of books, articles, and congressional hearings. Numerous publications have dealt with the history, goals, techniques and personality traits of the various terrorist organizations. While very little of the information contained in these documents appears to be directly related to the design of psychological deterrence systems, some of the general material on insurgency, counter-insurgency and terrorism is useful as background information for describing the range of intrusions with which a FEDS must be designed to cope. Representative examples of this literature are cited in Section 6.

Along with and basic to the specialized development of small-group combat tactics, the necessary fire power (and other technical requirements to implement these tactics) has been well developed. This development has resulted in a very large and poorly controlled inventory of sophisticated individual weapons and other combat devices which are readily available to terrorists for use in various forced entry operations including theft of non-nuclear weapons and industrial espionage. Recent developments in Southeast Asia, for example, will probably ensure ample supplies of U.S. military arms for terrorist use, especially for those terrorists who are subsidized by governments unfriendly to the United States. Thus, the design of a FEDS to prevent nuclear weapon theft may contain subsystems (components) which can be used as deterrents to non-nuclear weapon theft and, as well, have application to civilian-sector security problems.

3.1.1 Intruder Characteristics

The relevancy of the available psychological/behavioral literature to FEDS design is to a large extent a function of the personal characteristics of potential intruders. As noted earlier, the population from which intruder groups may be drawn is extremely heterogeneous. Further, the basis for sample selection, i.e., team recruitment, can be influenced by political, strategic, and tactical considerations which further obscure the general personal characteristics of intrusion team members. The problem of defining intruder characteristics makes it difficult to determine applicable psychological criteria for the design, test, and evaluation of a FEDS. A "best-educated guess" approach to terrorist personal characteristics provides the following gross generalizations:

(1) Age - The majority of intrusion team members can be assumed to be relatively young, e.g., late teens to early thirties. This assumption is based upon the age characteristics of known terrorist personnel, but does not preclude the possible inclusion of somewhat older individuals or even very young ones. The significance of age appears to be related to agility and endurance but not to muscular strength.

(2) Sex - The majority of the members of an elite terrorist assault team would probably be males; however, the inclusion of women in the team should not be ruled out, as some terrorist aircraft hijackers have been female and some guerilla troops, e.g., among the HUKS, frequently include women. Unfortunately, in view of regional variations in female vs. male anthropometry and motor capabilities, it is doubtful if any valid, ergonomic, sex-normative data can be obtained from the literature for FEDS design purposes. It is conceivably possible that certain hormonal characteristics might be relevant to FEDS design, e.g., chemical agents, but this would seem speculative at present.

(3) Psychological Processes - The intellectual functioning of potential, worst-case intruders may be assumed to be greater than population norms. Sensory and perceptual functioning, on the other hand, are probably more typical of the population at large. Thus, the FEDS should be designed to effectively deal with the full range of normal human sensory and perceptual mechanisms. Unfortunately, little normative data has been collected in the motivational context of an elite terrorist intrusion effort. Therefore, data relevant to human tolerance and performance levels under conditions of sensory overload or stress must be interpreted very cautiously. If data of this nature are used for the purposes of FEDS design, the extreme values of the normative data should possibly be considered more representative of terrorist norms.

(4) Personality and Motivation - Terrorist team members should be considered highly fanatical and dedicated to their cause. While their confidence and dedication are high, they also will not hesitate to make great sacrifices (including their own lives) if it will increase the chances for successfully achieving the mission. Their courage is extreme, and they may be expected to remain calm and confident, even under fire.

(5) Skills - The organization of the intruder team, especially the skill inventory, may be expected to be tailored to the characteristics of the target facility. In this regard, the organization can be expected to be similar to that recommended by HumRRO for Small Independent Action Forces (SIAF) (Olmstead et al. [3]) except that it may not be structured or manned to utilize the level of logistics support envisioned for the SIAF.

In considering the types of individuals who are likely to be involved in a full-scale, nuclear weapon theft attempt, it should be emphasized that the terrorist, the mercenary, and the common criminal attempting a break-in burglary of a home or business vary substantially. There is little correspondence between the three in motivation, goal, or modus operandi. The terrorist and mercenary levels of motivation are probably far higher than that of the criminal. The terrorist's goal is to achieve political publicity for his cause, even if not for himself, rather than clandestine personal financial gain, while the mercenary is primarily interested in personal financial gain. Discovery and combat are events that terrorists and mercenaries will accept, rather than forgo the goal. The specific design features and criteria of FEDS for preventing a criminal burglary would probably differ substantially for the nuclear threat scenario. Therefore, most of the behavioral literature dealing with deterring home and commercial burglary may be considered irrelevant to the FEDS design problem.

In the worst case, then, the FEDS must be designed to counter a threat which is characterized by:

1. The employment of small-group combat tactics of well-established effectiveness.

2. The choice and utilization of equipment suitably designed for such tactics.

3. The employment of tactics and equipment by terrorists whose main predictable psychological characteristics are high levels of motivation, training and capability.

4. A goal whose achievement is of utmost importance to the terrorists: theft of a nuclear weapon for purposes of international terrorism and/or blackmail.

3.2 Scenario

The major activities involved in a well-organized, high-level intrusion attempt occur in two general phases as follows:

Preparation Phase	(1) Selecting and organizing assault team (2) Planning assault attempt (3) Acquiring physical resources (4) Acquiring strategic information (5) Training assault team
Intrusion Phase	(6) Penetrating the NWSS (7) Penetrating the NWSU (8) Activities at NWSU (9) Escaping

In general, the activities involved in the preparation phase would be covert, and may not therefore easily be influenced by traditional deterrence measures. It is during the intrusion phase, which is primarily overt in nature, that deterrence systems should be effective.

The number of possible intrusion scenarios is practically limitless. Hence, in attempting to understand the means by which forced entries might be accomplished, a "typical" scenario will be examined (see Mayer and Pazzelle [1] for a more detailed description of adversary capabilities and probable intrusion techniques). This scenario assumes a relatively overt attempt by a small terrorist group with the mission of obtaining and removing an intact and operational nuclear warhead. While there are numerous other possible types of intrusion attempts (e.g., entirely clandestine collaboration with facility personnel), the overt, aggressive intrusion scenario appears to be the best for demonstrating the behavioral impact of FEDS. It should be noted that a real-world, overt, forced entry attempt would probably be more clandestine in its initial stages than the following scenario indicates.

The forced entry attempt is assumed to commence at some initial contact and proceed through a series of penetration stages until the target (the nuclear device) is reached. During any of these stages, the intruders and response forces are carrying out coordinated action within the framework of the FEDS mission and capabilities.

The initial penetration effort is focused on the outermost perimeter barrier. If the intruders have not previously been detected in the extra-perimeter area by routine surveillance or possibly intrusion detection sensors, perimeter barrier penetration should initiate a FEDS warning that an intrusion attempt is under way. Action by the intruders consists of an organized penetration attempt on the perimeter barrier by a handful of intruders, and may be preceded or accompanied by suppression of individual guards and/or by covering fire from the extra-perimeter area. Action by FEDS should consist of detection, initial evaluation of the tactical situation, such aggressive or passive responses as may be available at this stage, and alerting primary security forces. It may be difficult at this stage to determine if the entry attempt constitutes a maximum threat, i.e., from an elite terrorist group, or a less-than-maximum threat; e.g., by vandals or a protest group. In the latter case, a maximum response by the FEDS could produce undesirable injuries or deaths which would be incommensurate with the seriousness of the threat or the status of the intruders. However, it should be realized that at this stage the incorporation of a "merciful" response into the FEDS design at the expense of deterrence effectiveness could allow terrorists to gain a significant tactical advantage by posing as lower-threat-level intruders. The present scenario assumes that FEDS makes no distinction between levels of threat once the fact of a forced entry attempt at the perimeter barrier is established.

The sequence of events between initial (outer perimeter) and final (NWSU) penetration cannot be easily typified, since the tactical situation is highly fluid, with a great diversity of possible FEDS/intruder interaction. The intruders' tactics are to negotiate barriers, avoid contact with or otherwise counteract FEDS, and minimize penetration time. The FEDS' tactics are to prolong penetration time and to maintain contact with the intruders. Between initial and final penetration, there is no overriding reason for a lethal deterrence capability. In fact, the FEDS purpose is probably better served by confusion, containment and capture, since this might yield data useful in the prevention of future intrusion attempts.

The final penetration effort is at the NWSU. At this point, the FEDS response should be sufficient to completely incapacitate one or more intruders. Psychological design factors should be used to enhance the physical resistance of the storage unit, and disrupt the intruders' efforts to utilize whatever forced-entry equipment they have brought with them. It is difficult to estimate the relative strength of the intrusion and defense teams at this stage of the assault. However, it does not seem reasonable that a seriously weakened intrusion force could carry out an effective break-in effort against a strong and active defense. Hence, it must be assumed that during the previous stages the FEDS were either bypassed or seriously degraded. Thus, the storage unit FEDS should be entirely self-sufficient in terms of initiation of response, and source of available power.

Penetration of the storage unit initiates FEDS operations within the unit, hence making the removal of the nuclear device as difficult as possible. The deterrents would be designed for direct interference with the sensory and motor processes required for the task of obtaining and removing the nuclear device, e.g., interference with stability, locomotion, and vision, including the use of sensory stressors and chemical agents. The measure of last resort might be non-nuclear destruction of the device or even the storage unit itself.

4. NWSS SECURITY PHILOSOPHY

One behavioral approach to solving the security problems associated with the full threat continuum, i.e., deterring low-level threats without injury to the intruder, while deterring high-level threats at all costs, is represented by the maze concept. In this approach, the intruder(s) encounters a series of progressively more difficult, confusing and/or harmful physical barriers and obstructions. The farther into the system the intruder(s) goes, the greater the risks of detection, disablement, serious injury or death become. In general, this approach centers around completely denying the intrusion of all low-level threats, while denying and/or delaying the intrusion of high-level threats. Maze configurations may be designed and implemented such that penetration attempts become disorganized, with resulting confusion of the team members. It may even be possible to stop short of activating potential disabling or harmful subsystems by structuring the maze to insure that "negotiated survival" can be achieved at certain decision points.

The concept of delay is extremely important in current security systems philosophy. Each additional minute consumed by an intrusion force provides additional time for security forces to respond to and thwart the intrusion attempt. This reliance upon backup security forces implicitly accepts the notion that there does not presently exist a physical security system which may be considered completely fool-proof. Hence, well-trained, hopefully well-prepared security forces may be considered to be the ultimate line of defense, and all other physical security systems must be considered secondary to them.

In line with this philosophy, a great deal of emphasis is currently placed upon the human aspects of the security system. Communications, logistics, and training are all of primary importance. Physical barriers and detection systems are designed primarily to aid security forces in the conduct of their job. Psychological deterrents should be designed to perform the same function.

5. PSYCHOLOGICAL DETERRENTS-LITERATURE REVIEW

The literature search was conducted in three phases.

1. Location of the sources and titles of pertinent publications.

2. Establishment of criteria which governed the acceptance or rejection of an article for inclusion in the bibliography.

3. Reviewing acceptable items.

Only non-classified literature was reviewed for the purposes of this report.

Several approaches were used to locate the literature for review. The three primary sources were:

1. Computerized literature searches, including searches of

   (a) Defense Documentation Center (DDC)

   (b) National Technical Information Service (NTIS)

   (c) Psychological Abstracts Search and Retrieval Services (PASAR)

2. Individual contacts with authorities in the field, and

3. Libraries in the Washington, D.C. area.

An article was deemed acceptable only if it conformed to the following criteria:

1. The article had to contain either general background or behavioral information relevant to the design of FEDS hardware and associated security procedures.

2. The article had to contain information of a psychological or behavioral nature which was at least partly relevant to the deterrence of medium and/or high-level threats.

5.1 Psychological Aspects of Deterrence - General

Deterrents to nuclear theft may be thought of as being either primarily physical or psychological in nature; however, the distinction between the physical and psychological properties is not always clear cut as many deterrents have both properties. For example, a fence with barbed tape on top may influence the perceived difficulty of penetration of that fence while different fence configurations will result in different minimum penetration times, a physical performance consideration. The perceived difficulty of fence penetration is obviously more psychological in nature, and typifies the major emphasis of the literature review.

The primary consideration in deciding upon the potential usefulness of a psychological deterrent is the extent of its effects upon intrusion initiation and efficiency. More specifically, these effects should:

(1) be appropriate for medium and high-level threats,

(2) be reliable,

(3) produce no permanent serious bodily injury,

(4) appear rapidly after initial contact,

(5) be difficult to counter, and

(6) be produced by equipment which is reliable, cost-effective, and easily maintained.

Any potential deterrent which does not meet all of these criteria is considered inappropriate for use as a psychological deterrent to nuclear theft.

The psychological processes which might readily be manipulated for deterrence purposes include: (1) sensation, (2) perception, and (3) cognition. The manipulation of motivational, learning, and psycho-social processes appears to be more complex within the rubric of nuclear theft and is only discussed briefly because relevant, unclassified literature does not exist. In general, the more basic the psychological process, e.g., sensation and perception, the more amenable it is to deterrence considerations.

5.1.1 Sensory Processes

While each of the various human sensory systems is capable of comfortably detecting a wide range of stimulus intensities of appropriate form, each sensory system has certain intensity limitations beyond which the stimulus becomes noxious, or even painful, to the person involved. Literally thousands of studies have been conducted which demonstrate the deleterious effects these noxious stimuli may have upon human performance and higher order behavioral processes, e.g., decision making, problem solving, and memory.

While the number of noxious stimuli known to have aversive effects upon man is large, only a few of these appear to be appropriate for psychological deterrence purposes. Typical stressors which were rejected for possible use within the FEDS concept included compression and decompression, acceleration and deceleration, vibration and weightlessness. These stressors are obviously inappropriate to the static, open air conditions which characterize the NWSS. Stressors which were accepted as being of some potential deterrence value were: (1) noise, (2) radiation (including microwaves and visible light), (3) temperature, and (4) chemical agents.

Wilkinson [5] has identified six factors which may influence the extent to which environmental stressors have an influence upon human performance. The extent to which these factors hold true in the context of a NWSS intrusion attempt will depend upon the specific tactics involved in the intruders' planned scenario. The factors are: (1) duration of work on the task, (2) familiarity with the task and its associated stresses, (3) the level of incentive, (4) the character of the task, (5) the presence of other stressors, and (6) the aspect of the task which is most important.

5.1.1.1 Noise

Hundreds of studies have been conducted dealing with the effects of noise upon man. The number and variety of both independent and dependent variables that have been investigated is almost endless. Typical independent variables have included noise intensity, frequency composition, duration, regularity, relative location, and a wide variety of human mental and physical characteristics. Typical dependent variables have included physiological effects and the efficiency of mental and performance functioning under a wide range of task requirements. Comprehensive reviews of the effects of noise upon man have been prepared by several authors (Kryter [27; Broadbent [11]; Jerison [24]; Davies [16]; Poulton [36]; Buckley [14]).

In terms of the FEDS concept, there are several means by which noise might serve as a useful and efficient psychological deterrent:

(1) noise may act as an audible alarm system for the NWSS security force;

(2) noise may be used to warn the intruders that their presence has been detected;

(3) noise may produce interference with verbal communications between members of the assault team;

(4) noise may induce incapacitating physiological effects such as pain, dizziness, blurred vision, nausea, etc; and

(5) noise may have deleterious effects upon intruder intellectual and motor performance, hence slowing the completion of the attack.

The ideal location for a high intensity noise deterrence system would probably be inside or near the NWSU, and would be activated by unauthorized entry into the unit. The major drawbacks of this approach are (1) possible technological difficulties in the design of the system, and (2) susceptibility of the noise generation device to destruction.

Several studies have indicated that noise might have particularly strong effects upon intruders under the high-tension conditions of an intrusion attempt. More specifically, these studies (Shambaugh [38]; Barrett [8]; Broadbent [13]; Cohen et al. [15]) have shown that subjects exhibiting anxiety and introverted emotional characteristics are more susceptible to the effects of intense noise than are more relaxed and extroverted subjects. It is assumed here, of course, that due to the nature of the task, NWSS intruders would have a greater than usual degree of anxiety, and would be somewhat anxious about their precarious endeavor.

Audible alarm effects

While no studies dealing with the deterrence effectiveness of audible intrusion alarms were found, it is probably reasonable to assume that at the very least, covert intrusion attempts might be deterred or plans altered by the activation of an extremely intense audible alarm.

Speech Interference Effects

The effects of noise upon speech intelligibility are well documented. Numerous approaches have been taken to the measurement and quantification of speech disruption, the most well-known of which are the "Speech Interference Level" and "Articulation Index" (Kryter [29]). Specifications using these indices are given in terms of loudness of the speaker's voice, frequency composition of the masking noise, and separation distance between speaker and listener. Webster [41] provides a simplified, yet highly accurate, means of determining Speech Interference Levels under conditions of extremely high intensity noise . Morgan et al. [32] provide evidence that a 100 dB masking noise at frequencies comparable to the human voice (600-4800 Hz) is sufficient to preclude effective verbal communications between two individuals separated by a distance of six inches.

Physiological Effects

Several authors have presented evidence that exposure to extremely intense noises (greater than 120 dB) may result in disturbing physiological effects in human subjects. Dickson and Chadwick [17] reported that persons subjected to jet aircraft noises of approximately 140 dB for moderate time

durations have complained of a variety of symptoms associated with severe disequilibrium, e.g., loss of balance, dizziness, nausea, and involuntary eye movements (nystagmus). Similarly, Kryter [27] and Ades et al. [7] reported cases of ear pain, blurred vision, slight increases in skin temperature, dizziness, and nystagmus as a result of exposures to 150 dB noise levels. Some attempts have been made to explain deleterious noise effects upon performance in terms of disruption of vestibular function (Harris [19]; Nixon et al. [33]).

High intensity noises in the infrasonic (5-20 Hz) and ultrasonic (16-20 kHz) ranges may cause extreme disruption of a variety of physiological processes, although little empirical evidence has been gathered to support this viewpoint. Kryter [28] speculates that extreme infrasonics may cause extreme amounts of ear pain, dizziness, nausea, and possibly resonant vibrations in the chest, throat, nasal cavities, and eyes. Similarly, ultrasonics may be expected to cause nausea, headache, fatigue and tinnitus (ringing sensation in the ears). Acton and Carson [6] and Skillern [39] have demonstrated some of the hypothesized effects of ultrasonic noise. They note that the disturbing effects were especially evident in young and healthy individuals with sensitive hearing.

Performance Decrement Effects

The effects of noise upon measures of human performance are extremely varied, and are dependent upon numerous noise and task conditions. Conflicting experimental results are common in the literature as a result of this plethora of situational variables. Poulton [36] has attempted to explain these discrepant results in terms of the interaction of the negative (distraction, vestibular stimulation, startle response) and positive (arousal) effects of moderate levels of noise. Hence, at levels below 120 dB, noise has little, if any, systematic effect upon a variety of mental and performance tasks of a simple nature (e.g., Broadbent [12]; Brewer and Briess [9]; Helper [20]; Loeb et al. [30]; Plutchik [35]; Sanders [37]; Park and Payne [34]). At sound intensities in excess of 120 dB, and/or with tasks of a more complex nature (especially tasks involving complex sensorimotor functioning), more systematic effects begin to appear. In general, the greater the intensity and frequency, the greater will be the deficit in performance (Broadbent [11]). In addition, non-uniform (i.e.,

intermittent, or modulated) noise also produces greater performance decrements than uniform noise (Glass et al. [18]). The modulation of intensity may be more disturbing than the modulation of frequency (Miller [31]).

The mechanisms by which noise causes decrements in mental and motor performance are not well understood. Hence, a variety of theories have been presented. These include, (a) noise causes distortion of time perception and/or short term memory (Jerison [21], [22], [23]; Jerison and Arginteanu [25]; Jerison and Smith [26]), (b) noise affects vestibular functioning (Harris [19]; Nixon et al. [33]), (c) noise results in distraction away from the relevant task (Teichner et al. [40]), and (d) noise causes a "blinking" of the perceptual mechanism (Broadbent [10]). At extremely high levels of intensity, especially for infra- and ultra-sonic frequencies, physiological disturbances may also lead to severe performance decrements.

5.1.1.2 Radiation

Physicists distinguish between two fundamentally different classes of radiation: corpuscular and electromagnetic. As these two classes generally have radically different behavioral and physiological effects, they will be discussed separately. In-depth reviews dealing with the major behavioral effects of radiation have been presented by several authors (Poulton [36]; Furchtgott [48] and [49]; Thompson and Bourgeois [55]; Harlow [50]; Eakin and Thompson [45]).

Corpuscular Radiation

Corpuscular radiation consists of streams of atomic or sub-atomic particles traveling at speeds approaching that of light. These particles vary greatly in terms of their mass and electrical properties. Typical particles include helium nuclei, protons, deuterons, neutrons, electrons and positrons.

Corpuscular radiations affect man primarily as a result of the transfer of their kinetic energy to the cellular tissues they strike. Due to the relatively large amounts of energy involved, this transfer process usually results in the destruction of or damage to the cells impacted. Hence, behavioral effects are generally the result of cellular disruption within the nervous system. In general, this type of

radiation produces no painful or uncomfortable sensation in man during the exposure period, but the consequences of such exposures may become catastrophic over time. Due to the extreme effects of corpuscular radiation, and the long time factor leading to the consequences of such exposure, most of the available data relevant to behavioral effects have been collected through sub-human animal experimentation. Psychological effects are impossible to demonstrate in the absence of the associated serious physiological disruptions.

In review of its irreversibly harmful nature, and the lack of information directly relevant to the psychological/behavioral effects of corpuscular radiation on human subjects, corpuscular radiation may not be a likely mechanism for achieving psychological/behavioral deterrence. The potential danger to security forces and the additional safeguards required to protect them and other authorized personnel are further disadvantages.

Electromagnetic Radiations

Electromagnetic radiations consist of oscillating fields of electric and magnetic energy traveling at the speed of light. These radiations are generally classified according to their wavelengths or frequencies, where wavelength is inversely related to frequency. Typical electromagnetic radiations include: radio, radar, microwave, infrared, and ultraviolet as well as visible light.

Generally, the higher the frequency, the greater the amount of radiation absorbed by the cells of the body; while the lower the frequency, the further the radiation will penetrate into the body. At low to moderate intensities, radiation absorption does not typically cause extensive damage to the exposed cells because of the dissipation of the newly acquired energy in the form of heat.

The effects of electromagnetic radiation penetration and absorption can be categorized as follows: (1) thermal effects of microwave and infrared radiation, (2) non-thermal effects of microwave radiation, and (3) effects of visible light. These categories are discussed separately in the following sections.

Thermal Effects of Microwave and Infrared Radiation

The most dramatic thermal effects are produced by the microwave and infrared regions of the electromagnetic spectrum. At high intensities, severe burns and cellular destruction may occur on the outer body surfaces. As the thermal effects of microwave and infrared radiation are predominately physical in nature, only the threat of their use appears to be useful as a psychological deterrent.

Non-thermal Effects of Microwave Radiation

In addition to producing thermal effects, microwave radiation has frequently been cited as being responsible for non-thermal changes in integrated central nervous system activity (Thompson and Bourgeois [55]). The behavior consequences most frequently reported have been general disability, listlessness and increased irritability (Kevorkian [52]; Sadchikova and Orlova [53]; Jaski [51]; Sercl et al. [54]; Droqichina [44]; Edelwejn and Haduch [46]). However, some authorities believe these effects may be the result of indirect thermal effects upon metabolic and circulatory processes within the brain (Dahlen [43]).

Thompson and Bourgeois [55] have presented a review of numerous studies which have demonstrated that microwave radiation may have non-thermal effects upon sensory functioning and/or perceptual organization in man. More specifically, auditory, visual, and olfactory hallucinations, as well as altered sensory functioning, have been cited. Related to these findings is the fact that microwaves, under certain conditions, may be detectable by human subjects through "non-specific sensory channels" (Frey [47]). The literature appears to make little distinction between acute and chronic effects. To be useful as a psychological deterrent, the non-thermal effects of microwave radiation must be relatively immediate.

In general, the psychological and behavioral, non-thermal effects of microwave radiation are as yet not understood, and much debate remains over the conditions and underlying mechanisms by which these effects occur. Hence, the use of this approach in the FEDS program would appear to be highly speculative at present. As more data are collected, the effectiveness of microwave radiation as a psychological/ behavioral deterrent should be reassessed.

Effects of Visible Light

Electromagnetic radiation in the range of approximately 400-700 micrometers is detectable by the human eye and perceived as light. To be effective as a controllable psychological deterrent within the context of FEDS, light should be used externally at night or within the confines of the NWSU. Light, if intense enough, may be used under daylight conditions; however, the costs associated with high intensity light sources for daytime use would probably not be worth the level of deterrence achieved. In general, the effects of light upon human behavior may be traced to one or more of the following characteristics of light: (1) intensity (brightness), (2) dominant wavelength (hue), (3) purity of wavelength (saturation), and (4) spatial and temporal arrival patterns.

For the purposes of FEDS design, the effects of hue and saturation may be eliminated immediately, as the literature suggests no deterrence value for these characteristics; while hue has occasionally been associated with "mood", these effects are highly idiosyncratic. Insufficient intensity will, of course, result in degraded performance for most tasks (Poulton [36]). Excessive illumination (glare) will have the same effect. The proper amount of light to be used as a deterrent to potential intrusion attempts is extremely difficult to prescribe, as it has been shown that its effectiveness as an urban crime deterrent is highly dependent upon structural layout and usage (Wright et al. [56]).

The major difficulty involved in determining an optimum arrangement and level of deterrent lighting is related to the fact that both the intruders and the security forces require light in order to operate efficiently, yet may prefer darkness to preclude their detection by the opposition. The presence of optical intrusion detection systems may further complicate the design of the ideal lighting system. Little behavioral research directly relevant to the lighting of the NWSS has been conducted.

Fluctuating levels of illumination (flicker) may be of some limited use as a psychological deterrent. Intense flicker at rates of 5 to 20 cycles per second is known to cause attacks resembling epilepsy in certain susceptible people. More common is the illusory detection of motion, color, and/or patterns. These effects frequently lead to feelings of confusion and/or anxiety (Poulton [36]).

Random, intermittent application of lighting at various points around the outer security perimeter might produce greater amounts of uncertainty on the part of potential intruders. In addition, it would prevent the adaptation of intruders' eyes to a given level of illumination, thus further degrading performance capabilities. Extremely intense flashes of illumination might be used to produce "flash blindness" effects (Brown [42]).

5.1.1.3 Temperature

Extremes of heat and cold may serve as effective deterrents within the confines of the NWSU. The effectiveness of this approach is dependent upon three mechanisms: (1) performance degradation, (2) physiological tolerance limits, and (3) skin pain from momentary, high intensity thermal pulses.

Performance Degradation

Degradation of psychomotor performance has been reported in numerous studies for both heat and cold (e.g., Bell and Provins [57]; Pepler [73]; Wilkinson et al. [81]; Wing [82]; Kay [67]; Trumbull [78]; Dusek [64]; Peacock [71]). A few studies have also suggested the possible degradation of cognitive functioning (Viteles and Smith [79]; Mackworth [70]; Carpenter [63]) and attention (Wing [82]; Bursill [61]; Pepler [72]) under conditions of thermal stress. These effects upon mental functioning are probably the indirect result of discomfort and its consequent distraction, rather than any direct effects upon neural processes per se (Pepler [74]).

While thermal stress clearly has drastic effects upon human performance, the extent of these effects (for a given temperature) vary considerably, depending upon the nature of the task and the degree of motivation involved (Teichner [77]). It is not unexpected then, that for relatively short periods of time, individuals can compensate for thermal stress conditions by making a concerted effort to perform the task involved (Pepler [74]). Therefore, it might be expected that highly motivated terrorists involved in the theft of nuclear weapons might be relatively unaffected by adverse temperatures for a brief period of time.

Berenson and Robertson [58] have shown that performance degradation is generally first observed at temperatures of

approximately 75 percent of the physiological tolerance limits (described in the following section). These adverse effects may begin to disappear after a short while as a result of acclimatization to the adverse temperature (Blockley [59]). Therefore, a slight increase in the level of thermal stress to that approaching the physiological tolerance limit might reasonably be expected to serve as a more effective deterrent.

Physiological Tolerance Limits

Physiological tolerance limits are dependent upon a variety of factors including exposure duration, type of clothing worn and humidity. Trumbull [78] has presented data relevant to thermal tolerance limits for sitting, "normally" clothed subjects as a function of relative humidity and exposure duration. The temperature at which faintness, breathing difficulty or nausea occurred defined the tolerance limit. Typical tolerance limits were 125°F (52°C) for heat, and 30°F (-1°C) for cold (both for 1/2 hour exposure at 30 percent relative humidity). Lind [69] provides similar data relevant to thermal tolerance levels for sitting and working individuals. Continued exposure to thermal conditions in excess of the stated tolerance limits, and without protective garments, may result in cramps, exhaustion, and/or stroke in the case of heat; and shock in the case of cold (Buskirk and Bass [62]).

While thermal conditions in excess of the physiological tolerance limits would probably prove to be reasonably effective for deterrence purposes, there are several reasons why the use of this approach may be unsatisfactory. These are: (1) the expense, difficulty, and impracticality of maintaining the NWSU at a prescribed deterrent level, (2) the possibility that intruders may be wearing suitable protective garments, and (3) possible damage to equipment items and weapons when they are exposed to long-term, extreme thermal conditions.

Some of these drawbacks may be avoided, however, by a quick-acting, highly efficient heating or cooling system designed to be triggered at the onset of an illegal entry into the storage unit. Such a system might involve microwave radiation, or the dispersion of extremely hot or cold aerosols (e.g., steam, liquid oxygen, etc.). Not only would systems of this type produce intolerable temperature levels within the NWSU, but direct exposure to the thermal pulses emanating from these systems (e.g., microwaves, gas exhaust) could produce immediate extreme skin pain with comparatively minor damage to the outer layers of skin.

Skin Pain from Thermal Pulses

Heat pulses may be transmitted by means of conduction, convection, or radiation. The temperatures and exposure durations required to produce pain are known for each of these transmission modes. Blockley [59] has provided an excellent summary of the data related to the threshold requirements for each temperature transmission mode. More specific information may be found in the original source articles (Buettner [60]; Hardy [65]; Kaufman et al. [66]; Kissen and Hall [68]; Stoll and Green [76]; Webb [80]). Exposure to extremely cold surfaces or air currents may cause pain and or damage to outer skin surfaces. Contact with extremely cold, polished metal surfaces may cause skin to stick to the metal surface, while exposure to -10°F (-23°C) air moving at a mere five miles per hour can cause the skin to freeze within 30 seconds (Siple and Passel [75]). Again, an excellent review of tolerance levels for cold pulses (wind chill) is presented by Blockley [59]. All of the exposure requirements necessary to produce extreme pain to exposed skin appear to be within the realm of current technology.

5.1.1.4 Chemical Agents and Drugs

There are numerous chemical substances which are known to have noxious effects upon humans. The effects of these substances range from irreversible damage to the tissues of the human body, to subtle psychological changes with few directly observable effects. In light of the lethal or highly injurious nature of many of the chemical agents developed for warfare purposes, these substances should be excluded from consideration as potential psychological deterrents, pending final interpretation of EXECUTIVE ORDER 11850 by DNA. Similarly, the lack of information concerning possible irreversible, long-term, or delayed effects resulting from certain "psychoactive" drugs precludes their consideration for use as psychological deterrents.

The chemical agents which appear to be most appropriate for use within the framework of the FEDS concept are those resulting in irritating, yet non-injurious effects. Desirable effects would include watering of the eyes, coughing, stinging sensations, shortness of breath, repulsive odor and/or taste, dizziness and nausea. Numerous substances having these effects have been developed and used for law enforcement (riot control) and warfare (area denial) purposes.

Jones [84] provides an excellent, in-depth review of the use and effectiveness of the common law enforcement chemical agents (e.g., tear gas) and associated equipment. Related information is provided concerning dispersion techniques, countermeasures, and treatment. While Jones' text was intended primarily for use by law enforcement officials, and is geared towards riot control and mob dispersion, it provides adequate information for the evaluation of chemical agents as potential FEDS components.

Coates [83] has presented a comprehensive review of the potential use of non-lethal chemical agents for the disruption of enemy missions in combat situations. In addition to the irritating effects associated with law enforcement chemical agents, this author includes a discussion of several other chemical effects including itching, pain, imbalance, and temporary blindness and paralysis.

In general, the substances and techniques discussed by Jones and Coates would be easily applicable to the FEDS concept. Depending upon the nature of the chemical dispersion system, and the concentration of the substance used, chemical agents could be used inside and/or outside of the NWSU.

One great advantage to the use of chemical irritants is that they may be extremely difficult to counteract. This advantage stems from the fact that chemical agents can possess several deterrent characteristics simultaneously. For example, an opaque, sticky, and irritating aerosol may be particularly effective, since it occludes vision, impedes motor performance, and causes disabling physical discomfort. However, studies which evaluate the effectiveness of these "combination" chemical irritants are non-existent in the unclassified literature.

5.1.2 Perceptual Processes

The distinction between human sensory and perceptual processes is not clear cut. For the purposes of this review, perception may be regarded as the organization of sensory information into a meaningful image of the world. It should be noted that this "image" is by no means a one-to-one representation of the actual physical world, and it is this important property of perception which suggests some possible use for it in the design of psychological deterrence systems.

In terms of the FEDS concept, the visual perception processes of potential intruders would probably be the easiest to manipulate. Thus, it may be possible to design the physical attributes of a deterrence system such that they visually appear to be much more difficult to overcome than they actually are. An example would be a fence made to appear higher or more resistant to penetration than it actually is.

While basic laboratory research has demonstrated the existence of numerous illusory mechanisms which might possibly be used for deterrence purposes, little practical real-world research applicable to FEDS has yet been conducted in this area. The most readily applicable illusions would appear to be those relating to the size, distance, relative location, and apparent visibility of objects and/or persons (camouflage and mirrors). Discussions of specific illusions may be found in many sources (e.g., Hochberg [87]; Graham [86]; Dember [85]). Illusory mechanisms may be utilized to make the intruders' tasks appear more difficult than they actually are, make the tasks in fact more difficult to accomplish, and can even be used to make defensive systems appear easy to penetrate when, in fact, they are not.

The perceived effectiveness of physical deterrence systems can be evaluated with existing techniques. Survey methodology can be used with attack teams composed of highly trained volunteers (e.g., special forces units) both before and after a staged assault attempt to obtain information concerning both the pre- and post-assault perceptions of the team members. Preliminary studies utilizing this technique have been undertaken by behavioral scientists assocated with the Law Enforcement Standards Laboratory at the National Bureau of Standards [88].

Perceptually oriented defensive systems appear to be useful for deterring low- and medium-level threats by discouraging the initiation of assault and by influencing the perceptual organization of the intruders during their penetration. For high-level and worst-case threats, perceptually oriented defensive systems may not be as effective from a deterrence standpoint, although there may be some benefit served by influencing perceptual organization during attack.

5.1.3 Cognitive Processes

The cognitive processes traditionally include such mental activities as decision making, problem solving, creativity, memorization, pattern recognition, language and concept formation. The processes of decision making and problem solving are of key significance to the FEDS concept in that they represent processes which are more complex than the processes of sensation and perception, and may be expected to be much more difficult to influence for deterrence purposes.

For the most part, the pre-assault planning and decision making activities of potential intruders are beyond the realm of direct manipulation. The perceived difficulty of various attack scenarios will, of course, affect the planning phase of the potential assault. More purely cognitive deterrents might include techniques such as propaganda usage, staged assault attempts resulting in failure, and strict legal penalties. Very little information is available on the effectiveness of such techniques within the context of the terrorist threat.

Cognitive processes during or immediately preceding the actual intrusion phase may be more readily influenced than during the preparation phase. Any condition resulting in fear and/or confusion on the part of the attack group will have some effect upon their ability to make quick and accurate decisions. This may or may not be beneficial, as either logical or illogical decisions on the part of terrorists may lead to unpredictable consequences.

Three approaches relevant to the manipulation of intruders' cognitive processes were identified as being of potential use in the consideration of FEDS design. These were: (1) effects of information overload and/or conflicting information, (2) effects of the threat of apprehension or serious personal injury, and (3) effects due to strenuous physical activity. These approaches are discussed separately below.

5.1.3.1 Information Overload

Information relevant to the defense of a NWSS and/or the progress of an intrusion attempt may be selectively presented to the members of an assault team by a variety of means, the most practical being signs and loudspeaker messages. This information may be manipulated in a variety of ways to confuse

and/or disorganize the intrusion team. For example, the number of messages, the amount of information per message, the validity of the messages, and the temporal/spatial locations of the messages may all be varied. It must obviously be assumed that the intruders are familiar with the language used in the presentation of the information.

While it is difficult to predict what specific effects, if any, the content of a given message may have upon intruders' behavior, the frequency, validity, and amount of information per message, as well as the amount of conflict between successive messages may be designed to "overload" the intruders' cognitive functioning, hopefully resulting in confusion and anxiety. As a minimum, the presentation of unexpected information should momentarily distract the intruders from their ongoing activities. The confusion effects of information overload stem from the well-known fact that man is extremely limited in his ability to process incoming information (Fitts and Posner [95]; Poulton [36]). When two or more messages are presented simultaneously, it is extremely difficult to adequately process the information contained in both. If the information contained in one or both of the messages is familiar, and the presentation rates of the two messages is similar, it may be possible for a person to alternate his attention between the two messages sufficiently to receive both. But if the information of both messages is unfamiliar, and the presentation characteristics (e.g., speed, volume, etc.) are dissimilar, both messages may not be satisfactorily monitored. Under the latter circumstances, the person will frequently listen to only one of the two messages, and will hear nothing of the other message, with the possible exception of a few key words (Cherry [90]; Cherry and Taylor [91]; Broadbent [12]). This partial information from the unattended message may cause an attempt to mentally reconstruct the message, thus leading to confusion and/or anxiety when this is found to be impossible (particularly if the lost information is felt to have been of extreme importance). The amount of information lost is primarily dependent upon: (1) the number of simultaneous messages presented, (2) the message presentation characteristics, and (3) the degree of uncertainty about the information content of the messages (Fitts and Posner [95]).

For the purposes of psychological deterrence, an appropriate means of information overload presentation would probably be the loudspeaker. Thus, numerous loudspeakers positioned throughout the NWSS simultaneously broadcasting

contradictory, pre-taped messages might (1) provide contradictory information to different members of the intrusion team, (2) provide contradictory information to a given member of the team, (3) cause confusion and/or anxiety about partially attended-to information, and (4) distract the intruders from their ongoing activities. However, caution must be exercised in the use of loudspeaker messages to ensure that response force members do not become confused as well.

Poulton [36] has presented an excellent review of the effects of simultaneous loudspeaker presentations. In addition to the considerations mentioned earlier in this discussion, he presents evidence that information presented from a previously quiet loudspeaker may prove to be particularly distracting, especially when it follows a lengthy presentation from one or more different loudspeakers.

Numerous authors (e.g., Klemmer and Muller [99]; Alluisi et al. [89]; Cumming and Croft [92]) have demonstrated that as information overload occurs, performance of ongoing tasks deteriorates. Finally, the concept of presenting too much or too little sensory and/or perceptual information (removing cues and presenting conflicting cues) may result in deterioration of task performance.

5.1.3.2 Personal Threat

The threat of serious personal injury and/or apprehension by security forces may be used to achieve psychological deterrence. In many respects, this threat may be considered the fundamental factor basic to all forms of deterrence. Thus, any procedure or technique which increases the likelihood of personal injury or capture may be expected to decrease the likelihood of an intrusion attempt being made. Furthermore, the more obvious the threat involved, the more deterrence value it may be expected to possess.

It follows from this rather simple analysis that potential threatening conditions within the NWSS should be made as obvious as possible to all persons within the immediate vicinity. The presence of well-equipped security forces, automatic intrusion alarm and counter-intrusion systems, and signs mentioning the "authorized use of lethal force" should be clearly visible.

Very little empirical information applicable to predicting the effectiveness of personal threat as a deterrent is available. Poulton [36] reviews literature which indicates that inappropriately high levels of "arousal" may degrade performance and incentive. However, within the context of the high-level intrusion attempt, these data may be suspect, as the mechanism of "inappropriately high arousal levels" may not be applicable to the terrorist personality.

Swann [104] has compiled a bibliography and presented a brief review of the literature dealing with military combat suppression. Most of the papers he reviews deal with the suppressive effects of conventional weapons (e.g., Naylor et al. [101]; Polmer et al. [103]; Terry [105]). While these reports have generally failed to provide definitive knowledge of the psychological effects of weapons, one relevant finding was uncovered. Mills and Yale [100] have shown that a probability of being incapacitated by opposing weapons fire of approximately .005 is sufficient to cause military personnel to take cover and avoid using their own weapons. Kenney et al. [98] have reported the means by which this probability and inference were determined; however, the report's contents are classified. A related study not included in the Swann bibliography was reported by Olley and Krauss [102]. These authors investigated a variety of variables which they felt might be influential in the decison of military troops to fire in combat. They found the most influential variable to be "ordered to shoot," and the least influential to be "proximity of target." Moderately influential (all rated to be equal in significance) were "risk from enemy fire," "target identifiability," and "others in group firing."

5.1.3.3 Strenuous Physical Activity

Strenuous physical activity on the part of intruders may have several beneficial effects for deterrence purposes. Most obvious is the momentary discomfort (e.g., sweating, cramps, breathing difficulty) associated with extreme physical exertion. Second, violent exercise is known to temporarily reduce the efficiency of brain functioning (Hammerton and Tickner [96]). Finally, muscular fatigue following strenuous exercise may result in uncontrolled muscular movements (Carpenter (63]; Hammerton and Tickner [97]).

While the physical and mental effects of extreme physical exercise may be applicable to FEDS design, the precise control of these effects may be difficult to achieve. For example, the effects are dependent upon the general fitness of the individuals involved (Poulton [36]), and submaximal exertion may actually result in improved physical and mental performance (Davey [93] and [94]). In general, FEDS should be designed to ensure a maximum level of intruder physical exertion, with little opportunity for rest or relaxation.

5.1.4 Psycho-social, Learning, and Motivational Processes

As was the case with cognitive processes, the direct manipulation of potential intruders' psycho-social, learning, and motivational processes prior to the actual assault attempt appears to be impractical for high-level to worst-case threats. The specific nature of personality traits, social interactions, training, and motivating political and economic ideologies leading to an intrusion attempt is highly speculative at this time, but appears likely to be formed as a result of years of discontentment and radical association. As such, these processes seem presently to be relatively stable in nature. The manipulation of these same processes during the actual intrusion attempt may have some very limited practical significance for FEDS design, but it is unclear at present how these processes may best be utilized for deterrence purposes.

5.2 Summary

An unclassified literature review was conducted to identify possible techniques and mechanisms that might be useful within the context of the FEDS Program for psychologically deterring nuclear weapon theft. Generally, this literature indicates that while human psychological/behavioral processes can be directly manipulated by various means, little definitive empirical data was found to be directly related to actually achieving psychological deterrence for various postulated levels of threat. Basic (laboratory) and limited applied (field) research results concerning impacts on human sensory, perceptual and cognitive processes have been cited only to show the potential value of a variety of techniques. Research dealing with human psycho-social, learning, and motivational processes appears to be even more inadequate and highly speculative in nature with respect to achieving deterrence.

5.3 Implications for Future Research

Critical topics associated with the potential usefulness and reliability of psychological deterrence mechanisms within the FEDS context and the nuclear weapon theft application include: (1) the level of threat which must be deterred, (2) the type and quantity of intelligence data available to unauthorized intruders, and (3) the selection and use of countermeasures appropriate to the intelligence information available. The unclassified deterrence literature reviewed does not effectively deal with these issues. To better define and understand these topics, all pertinent classified documentation must be critically reviewed and evaluated, assuming that such documentation exists.

While certain psychological deterrents may be expected to be highly effective against relatively unprepared and moderately motivated intruders, higher levels of motivation and the use of, in many cases, simple countermeasures could greatly reduce the effectiveness of such deterrents. For example, the desired effects of high intensity noise and confusing loudspeaker messages may be negated by using ear-covers; the effects of high-intensity light negated by using goggles; the effects of certain radiations minimized or eliminated by wearing reflective clothing (e.g., tin-foil); the effect of chemical irritants reduced by using gas masks, etc. Alternatively, the source of the deterrent may be destroyed or, in the case of chemical irritants and drugs, use of an appropriate counter-actant would neutralize the effects.

Clearly, an extensive amount of definitive behavioral impact research should be undertaken by DNA in the FEDS Program to ascertain the actual and relative (comparative) deterrence values of many if not all of the potential techniques and mechanisms cited in this report. Table 1, presented on page 35, may be useful to DNA in its determination of research priorities and possible directions for system development efforts. At this time, the table represents the authors' preliminary opinions as to the likelihood of achieving psychological deterrence for low, medium, high, and worst-case levels of threat. It should be noted and emphasized that the unclassified literature cited in this report does not directly support or negate the judgments made, as the reported studies do not consider the level-of-threat concept.

In conclusion, the behavioral/psychological design parameters of a system that will, in fact, deter high-level and worst-case threats are, at present, unknown. The uncertainties reflected in table 1 may be interpreted as justification for (1) developing mechanisms (devices) and techniques (procedures) subject to feasibility testing, (2) conducting controlled behavioral impact studies to determine the level of psychological deterrence achievable, and (3) conducting cost/effectiveness analyses. All deterrence systems, regardless of their degree of sophistication, should be backed up by well armed, well prepared security forces, with special emphasis placed upon the "weakest links" of the system.

Table 1. Level of Threat - Hypothesized Psychological Deterrent Impact

	Low			Medium			High			Worst Case		
	Yes	No	U*	Yes	No	U*	Yes	No	U*	Yes	No	U*
Noise Effects												
Audible Alarm	X			X				X			X	
Speech Interference	X			X				X			X	
Physiological	X			X					X			X
Performance Decrement	X			X					X			X
Radiation Effects												
Corpuscular		X			X			X			X	
Electromagnetic												
Microwave			X			X			X			X
Infrared			X			X			X			X
Visible Light	X			X				X			X	
Temperature Effects												
Performance	X			X					X			X
Physiological Tolerance	X			X					X			X
Chemical Agents & Drugs	X			X					X			X
Perceptual Distortion & Disorganization	X			X			X					X
Cognitive Functioning												
Information Overload	X			X			X					X
Personal Threat	X			X					X			X
Strenuous Physical Activity	X			X					X			X
Psychosocial Influences			X			X			X			X
Learning Processes			X			X			X			X
Motivation Influences	X			X					X			X

*Uncertain.

6. BIBLIOGRAPHY

This section provides a bibliographic listing of the source materials referenced in the preceding sections of this report. The references are grouped alphabetically according to the major topical areas discussed. While the references dealing with each topical area should by no means be considered exhaustive, they appear to be, in the opinion of the authors, the most important and representative documents related to the psychological deterrence of nuclear theft. Related sources of lesser importance are discussed in many of the references cited.

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16. ABSTRACT (*A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.*)

A review of the unclassified literature dealing with psychological deterrents was conducted for the Defense Nuclear Agency (DNA). Its purpose was to identify techniques that might be useful in DNA's Forced-Entry Deterrent Systems (FEDS) Program for psychologically deterring nuclear weapon theft. The review indicates that while human psychological processes (sensory, perceptual, and cognitive) can be manipulated by various means, definitive empirical data are lacking which directly relate to deterring nuclar weapon theft. Behavioral impact research should be undertaken by DNA to (1) ascertain the deterrence values of the many techniques identified and (2) test the hypotheses implicit in the FEDS concept.

17. KEY WORDS (*six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons*)

Behavioral impact; cognitive processes; nuclear weapon theft; perceptual processes; psychological deterrence; security systems; sensory processes; threat analysis

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