ARMY RESEARCH LABORATORY

Owning the Environment: Stealth Soldier—Research Outline

by Tomasz R. Letowski

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14. ABSTRACT
Recent U.S. Army focus on the dismounted squad as the strategic formation in the current and future operational environments brings into focus lethality and force-protection gaps at the individual Soldier and small dismounted unit level. Successful and safe operations of small units in current operational environments can be enhanced by the development of new Soldier- and squad-level stealth and deception technologies and principles of operations. Both offensive and defensive stealth operations can be force multipliers and reduce the amount of friendly casualties. The current report presents an historical context of deception and stealth in military operations and outlines research needed to develop new safeguarding technologies for the dismounted Soldier. The document outlines the proposed research on sensory aspects of owning the environment and on the means to confuse the enemy regarding intended actions. An emphasis of the short- and medium-term objectives of the proposed research is on the acoustic elements of stealth and deception, due to their increasing viability and expected effectiveness for small squad operations.

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Contents

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1. Background

Deception is the act of conveying, concealing, decoying, or denying information undertaken to deliberately mislead an adversary as to the intention and capabilities of conducted operations. It is an important element of the force protection efforts made by the U.S. Army and the armies of the other countries. In short, deception occurs when someone manipulates the perception of someone else in order to achieve an advantage over the other party. More formally, *military deception* (MILDEC) is defined as a group of actions executed to deliberately mislead adversary decision makers as to friendly military capabilities, intentions, and operations, thereby causing the adversary to take specific actions (or inactions) that will contribute to the accomplishment of the friendly mission (Sharp, 2006).

Various forms of deception are used in military operations to provide cover for the individual, small unit, and large army activities. These include physical, multi-media, and psychological (e.g., propaganda) means. Taxonomy of the main forms of deception referred to in military publications (e.g., Dunnigan and Nofi, 1995; FM 20-3, 1999; FM 90-2, 1988) is shown in table 1.

Table 1. Basic forms of deceptive military activities.

Means	Forms	Description
Deceiving Maneuvers or Actions	Feint	Secondary attack with the purpose to divert the adversary's attention away from the incoming main effort attack.
	Demonstration	A show of force without contact with the adversary in the area where the contact is not sought with intent to deceive the adversary and cause him to select an unfavorable course of action.
	Ruse	False information (e.g., documents, recordings) intended to be discovered by and subsequently deceive the opponent.
	Display Simulation Portrayal	False static object(s) intended to show non-existent structure (simulations, displays) or to suggest incoming false action (portrayal).
Camouflage	Disguise Concealment	Hiding an object or action from being detected by disguise (e.g., painting over) or concealment (e.g., smoke screen).
Decoy	Visual Acoustic Olfactory	An object, signature, or action intended to draw away the attention of the adversary from other objects or actions.

The science and art of deception are as old as the human race and even nature itself. Displaying apparent fitness by animals during mating season or beating of the chest by dancers during some tribal rituals of war are the natural displays of deception. Some animals can change color to match the background or to mimic other creatures (e.g., octopi, amphibians, lizards). The same

applies to several plants (e.g., orchids) which rely on mimicry to achieve pollination, obtain food, or to exploit perceptual preferences of animals (Schaefer and Ruxton, 2009).

From the earliest times, the ability to use deception has been regarded as an important quality of military commanders. The Chinese general Sun Tzu who lived in the sixth century BC wrote in his book *Art of War* that "All war is deception" (Sun Tzu, ~510 BC). The Chinese *Book of Qi*, probably written during the same time period by an unknown scholar, lists 36 basic deceptive stratagems to be used in politics, war, and civil interactions (Verstrappen, 1999). All the deceptive activities listed in table 1 have their origin in the *Book of Qi*. Some examples of the stratagems are (Wikipedia, 2011):

- *Create something from nothing* (simulation),
- *Stomp the grass to scare the snake* (demonstration),
- *Deceive the heavens to cross the ocean* (ruse),
- *Besiege Wei to rescue Zhao* (feint),
- *Slough off cicada's golden shell* (camouflage), and
- *Openly repair the gallery roads but sneak through the passage of Chencang* (decoy).

The most well-known act of deception in the ancient times was the Trojan horse described in Greek mythology (e.g., Dunningam and Nofi, 1995). The wooden horse, with a concealed squad of 30 Greek warriors, had been brought to the city of Troy as a war trophy and led to the destruction of Troy after a fruitless 10-year siege of the city by the Greek army. Another ancient example of similar deception was the conquering of Jaffa by Egyptian General Thot in ~1450 BC (LeHockey, 1989). General Thot feigned being defeated and placed concealed soldiers in the baskets given as gifts to the city. The U.S. Army units that conducted the deceptive *Hail Mary* maneuver during the 1991 Persian Gulf War that surprised Iraqi forces used the apt clandestine name *Task Force Troy*.

In medieval Japan, special forces employed by local shoguns called *ninjas*, who often operated at night, wore dark clothing and face covers in order to blend well with the darkness of night. In medieval Europe, the deceptive maneuvers of Russian forces led by Alexander Nevsky, the prince of Novogrod, forced the enemy heavy cavalry to fight on slippery ice and led to the defeat of the Livonian Knights' army in the famous Battle on the Ice (1241). The deceptive tactics used by Alexander Nevsky have been echoed in the writings of Francesco Guicciardini (1483–1540), Italian historian and statesman of the Renaissance period, who said that "Success in war is obtained by anticipating the plans of the enemy and by diverting his attention from our own designs" (cited by Sharp [2006]).

The retreat of the French Army of Napoleon Bonaparte from Moscow in 1812 was made very difficult by the deceptive *Tarutinski Maneuver* performed by the Russian Army led by General

Mikhail Kutuzov (Karankevich, 2006). The Russian Army abandoned its defensive position around Moscow and moved stealthily behind the French forces to cut their supply lines. Many deceptive actions were performed during the American Civil War and the Confederate General Thomas "Stonewall" Jackson (1824–1863) once remarked that "Always mystify, mislead, and surprise the enemy, if possible…" (Johnson and Buel [1884–1888]).

A famous act of deception during World War II was an operation, *Quicksilver,* which involved placing a ghost army at Pas de Calais to mislead the Germans as to the actual site of the invasion of the European Continent (Normandy) by the U.S. and British forces. Another example of deception was fake munitions and ration dumps used by British General Bernard Montgomery during the Battle of El Alamein with the German Panzer Corps of General Rommel. Less known, but equally effective, were the cloaked operations behind heavy smoke screens by the Russians (*maskirovka*) during the crossing of the Dnieper River in October 1943, and during the battle of Lvov-Sandomierz in July 1944 (Armstrong, 1988).

Many forms of deception were used during World War II by the highly secret 23rd Special Troops brought to Europe after D-Day by the U.S. Military to deceive and confuse the retreating German Army. This 1100-man unit made up primarily of artists was equipped with various visual decoys. These included inflatable tanks, jeeps, etc.; powerful loudspeakers mounted on halftracks to broadcast sounds imitating tanks and troops movements; disguise clothing; and various pieces of radio equipment to create phony radio traffic. Many details of their operations are still kept secret, but the unit is credited for several successful U.S. Army maneuvers, most notably Operation Viersen (Rhine crossing).

The post-World War II era is also rich in examples of deception, including incidents during the Vietnam war, the 1973 Middle East War, Operation Allied Force (the Kosovo war), the 1991 Persian Gulf war, the Hezbollah deceptive tactics used in the 2006 Summer War with Israel, and many others (Latimer, 2001; Acosta, 2011). The deceptive actions used in these wars included all the forms of deception listed in table 1. Some of them were very elaborate and required months of preparation. Many of them involved various communication and dissimilation means including the use of public media and information networks.

The impact of deceptive activities for the final outcome of military campaigns has been significant across history and generally has been highly acclaimed. However, such activities also have had their critics. The most outspoken critic was Prussian General Carl von Clausevitz (1780–1831), who wrote in his book *On War* that deception on the battlefield is only effective on the large scale since individual commanders usually only have a foggy idea about what is going on (Clausevitz, 1832). Similar views are expressed by several other military writers (e.g., Keegan [2003]). However, an analysis of military operations since 1914 shows that deception almost always led to surprising the enemy—an advantage that is hard to achieve without some form of deception (FM 90-2, 1988).

2. Theory of Deception

Deception is a deliberate act of misleading the other party about planned actions or about the past or current events in order to create false beliefs or expectations. The act of deception can be inter-personal, inter-organizational, or may have a form of projecting a false image to the general public. In the military context, deception is used as a means of overpowering the enemy or a means of survival. Knapp and Comadena (1979; p. 271) offered a general definition of deception as "the conscious alteration of information a person believes to be true in order to significantly change another's perceptions from what the deceiver thought they would be without alteration." In this definition alteration means any form of lying, both verbal and non-verbal. Buller and Burgoon (1996; p. 113) also equated deceiving with lying and defined deception as "a sender's knowingly transmitting messages intended to foster a false belief or conclusion in the receiver." However, deception and lying are not always the same, and lying is just one form of deception (Chisholm and Feehan, 1977). In the *Model of Deception* proposed by O'Hair and Cody (1994), various forms of deception include evasion, concealment, lying, overstatement, or collusion. Whaley (1969) distinguishes between the two types of deception: dissimulation (hiding the real) and simulation (showing the false). The main considerations in creating either type of deception are its potential for being detected (e.g., addressed by the military in the form of Operational Risk Management [ORM]), harm to the targeted party, harm to a third party, potential loss of trust and respect, relational costs, and positive consequences such as expected gains.

In many cases, deception is recursive in nature, and one party is trying to deceive another party on the assumption that they know what the other party is expecting the first party to display. Cohen (2007) cited a well-known story to clarify the recursive character of deception:

> The Russian and U.S. ambassadors met at a dinner party and began discussing in their normal manner. When the subject came to the recent listening device, the Russian explains that they knew about it for some time. The American explains that they knew the Russians knew for quite a while. The Russian explains they knew the Americans knew they knew. The American explains that they knew the Russians knew that the Americans knew they knew. The Russian states that they knew they knew they knew they knew they knew they knew. The American exclaims "I didn't know that!"

The human reasoning fallibility allowing one to be deceived and led into an erroneous conclusion results generally from common beliefs that effects should resemble their causes, misperception of random effects, misinterpretation of incomplete or unrepresentative data, biased evaluation of ambiguous and inconsistent data, motivational beliefs, relying on second-hand information, and exaggerated impression of social support (Gilovich, 1991). A need for

deception may be motivated by desire to exploit the other party, greed, utility, malevolence, or benevolence. But while deception is commonly seen as an unethical behavior, it may also serve some well-justified purposes such as saving lives.

3. Stealth Operations

The critical elements of deception in military operations are activities intended to hide the presence, movements, strength, and intention of friendly forces from the adversary. Many activities listed in table 1 are operational means to achieve these goals. They are all of the utmost importance to the success of any military action, and they are together referred to in this report as s*tealth operations*, although they include both forms of force projection—hiding and magnifying. The stealth operations are supported, for example, in the U.S. Army's field manuals FM 90-2 (1988) and FM 20-3 (1999) as camouflage, concealment, and decoys (CCD) tactics to hide, disguise, decoy, or disrupt the appearance of military targets. The CCD tactics are based on seven critical rules of avoiding detection or identification:

1. Identify the adversary's detection capabilities,
2. Avoid detection by the adversary's routine surveillance,
3. Take countermeasures against the adversary's sensors,
4. Employ realistic CCD countermeasures,
5. Minimize movement,
6. Use decoys properly, and
7. Avoid predictable operational patterns.

In support of these tactics, the U.S. Military developed various CCD systems to protect real ships (e.g., nulka decoys, chaff decoys), aircraft (e.g., ALE-55 towed fighter, decoy drones), and land vehicles (e.g., inflatable M1 Abrams tanks) from being targets of missile attack and to be able to develop a stealth attack on their own.

The criticality of stealth operations to military success is evident by their inclusion in the tactics, techniques, and procedures (TTPs) of the U.S. Army. Stealth operations are also addressed in the U.S. Army MANPRINT program in the Soldier Survivability (SSv) Domain requirements. The SSv Domain was established in 1994 to assist developers, evaluators, and decision-makers in assessing the degree of protection a system provides. One of the six components of SSv addresses "Reduction of Detectability of the Soldier" that focuses on the detectability of the system signature (visible static and moving, visible optical, thermal/infrared, radio frequency, etc.) (Zigler and Weiss, 2005).

4. Military Footprint

Current and past research in stealth operations has been aimed at minimizing the footprint of such military systems as tanks, helicopters, and wheeled and tracked combat vehicles. The military footprint is the area within which an activity or an object at the deployed location is detectable. The footprint reduction of the military systems primarily involves long-range signatures such as electromagnetic and thermal (infrared) signatures but also addresses visual and more recently acoustic signatures. Some of these signatures are affected by the time of the day (e.g., day vs. night) and the type of activity (e.g., rest vs. movement). For example, visual footprint is not only dependent on the reflected or emitted light but it also depends on the back light (contrast). Detection of the footprint is also dependent on environmental conditions. For example, sound travels further in cool and moist air than it does in hot and dry air. In some cases, the goal of stealth operations is not necessarily to hide an object (footprint reduction) but to make it resemble another object (e.g., radio antenna disguised as a flag pole).

An individual Soldier's footprint includes visual, auditory, thermal, and olfactory signatures. Both the Soldiers themselves and their personal equipment (clothing, weapons, optical devices, etc.) contribute to these signatures. Most of the footprint reduction techniques that can be applied to military platforms can be also applied to individual Soldiers. However, their effectiveness and form of implementation may differ. There are also some potential individual-Soldier and small-team specific techniques that could be explored. Some of such techniques are addressed in the proposed research.

5. Individual Soldier and Small Team Stealth

The written accounts of deception in military operations are understandably focused on major operations that have changed the course of a war or an individual campaign. Second in line are large air-, ground-, and water-bound platforms that are both very powerful and very expensive and need to be well protected. Much less has been written about deception tactics used by individual Soldiers and small military units (squads), although there are some highly publicized cases of master spies and small military and guerilla team activities. One example is the elusive hit-and-run tactics of small guerilla groups run by *Swamp Fox* (Francis Marion) and *Carolina Gamecock* (Thomas Sumter) in the South during the American Revolution (Lumpkin, 2000). The most intriguing common thread of all these activities is improvisation. Improvisation and the opportunistic use of resources at hand are also still recommended in the current U.S. military texts, such as field manuals, as the key elements of deception and stealth operations available to individual Soldiers and small teams.

Although there is general support for and clear recognition of the value of stealth operations in military literature, there is very limited scientific and technological support for it at the small team, individual Soldier, and security personnel level as opposed to larger scale- and military system-related deceptive techniques and operations. The focus of the stealth operations technologies supporting the individual Soldier alone or as a member of a small unit such as a dismounted squad is historically mostly limited to visual decoys, paints, and camouflage battledresses such as the Army Combat Uniforms (ACUs) and improvisation.

The main individual stealth technology to date is visual camouflage. Personal visual camouflage is as old as hunting and wars. Camouflage was used by, among others, American Indians (face painting, twigs), Australian Aborigines (mud, twigs), and *ninjas* in the XIVth century Japan (clothes) (e.g., Crowdy [2006]). However, even though visual personal camouflage is currently a common stealth technique in military operations, it is still a relatively new military practice in the modern world. Until the XIXth century, that is, until the Napoleonic Wars, American Civil War, and the introduction of khaki uniforms by the British Indian forces (Barthorp, 1988), the Soldier wore bright, attention-getting uniforms that were the symbols of pride and status but also clearly visible targets (Behrens, 2002, 2009; Hartcup, 1980; Newark et al., 1988). The khaki uniforms (battledresses) were uniformly introduced to the entire British army in 1902 and soon after adopted by other armies including the United States (1902), Russia (1908), and Germany (1910). By the end of the World War I, all the involved armies were wearing some form of camouflage battledresses. The widespread use of camouflaged helmets painted or covered in drab or green originated in post-World War I Germany.

The renewed interest in camouflage was fueled by the development of long-range firearms and various stealth and deceptive operations which blossomed during and after World War II. The practice of camouflage painting on tanks, trucks, ships, and helicopters became a worldwide practice through many years. In addition, various new passive (blending with the background) and active (replacing an object with a replica of the background) camouflage means for large military platforms have been under development in recent years for the visible light sources (Moynihan and Langevin, 2000; Highfield, 2002; Sen, 2002), sound waves (e.g., sonar [Zhang et al., 2011)]), electromagnetic spectrum (e.g., radar [Jewish and Sweetman, 1997]), and thermal detectors (e.g., infrared detectors [Jewish and Sweetman, 1997]) but—with the exception of new patterns of camouflage for battledresses—with focus on large military platforms. However, despite a large body of research on effective camouflage patterns conducted during the last 100 years in many countries, the limits of visual deception techniques and the effectiveness of various deceptive means in various environmental conditions for individual Soldier or small squad operations are still not well known. The knowledge about effective camouflage "patterns" is even more limited in the case of auditory and olfactory senses. In addition, current technological advances in creation of auditory and olfactory signals seem to be underutilized in the development of environment manipulation techniques for enhancing stealth.

The current focus of U.S. Army doctrine on the dismounted squad as the strategic formation, *the tip of the spear*, in the current and future operating environments calls for more research and development efforts in providing stealth- and deception-bound means for the squad and its members. During recent international conflicts, the squad became the decisive ground force to execute at the point of attack either alone or as a unit of a larger force. This requires increased focus on a squad's ability to be both more lethal but also better protected from potential harm.* One special consideration in developing new stealth technologies is to decrease the current TRADOC-required concealment range from 35 m to 15–20 m.

As recently as 2011, Dr. Marilyn Freeman, Deputy Assistant Secretary of the U.S. Army for Research and Technology, warned that "There is insufficient FORCE PROTECTION to ensure highest degree of survivability across the spectrum of operations." The need for enhanced force protection of individual Soldier and small units has been currently regarded by the U.S. Army Science and Technology Advisory Group (ASTAG), which is co-chaired by the U.S. Army Acquisition Executive and the Vice Chief of Staff (Army), as the top priority challenge for the U.S. Army. The focus of the challenge is on reducing the number and severity of injuries and casualties by increasing the level of individual protection. In this context, the stealth operations that deceive the enemy about friendly troops' presence and movements are to be considered the important means of such increased protection.

6. Research Outline

The aim of the proposed research is to develop novel means to minimize detection of intended activities through sensory diversion and by presenting false information to the enemy about the surrounding environment. Such means needs to be applicable to stationary presence and both defensive and offensive maneuvers. The first step in reaching this goal is an in-depth understanding of the perceptual constraints of sensory and cognitive judgments as well as the physical limitations of the stealth behaviors and sensory diversions. The research is intended to develop a theoretical basis and technological means supporting both individual Soldier and small unit stealth operations (e.g., Special Forces activities, scouts, snipers, Soldiers stranded behind the enemy lines, etc.). The proposed program is intended to address multisensory and dynamic means of stealth and goes beyond traditional visual stealth and deception, which have been the focus of previous military operations. The focus of a multisensory approach is important since the easiest way to detect something deceiving is if this "something" has one of its sensory attributes missing or wrong (e.g., smell). An example of a promising new area of multisensory research is perception of events that interact with other events' boundaries. Initial research conducted at Washington University indicates that short events, which coincide with other

* The task of coordinating the efforts in developing Army superiority at the dismounted squad level in August 2011 was assigned to the TRADOC-led Squad as a Strategic Formation Integrated Capabilities Development Team (SaaSF ICDT).

events' boundaries, are perceived differently and more difficult to detect than when they occur within the boundaries of the primary event. However, these differences do not seem to be consistent across temporal, spectral, and spatial boundaries of the main event. The specific research program outlined in this proposal is focused on auditory and visual information but the scope of the long-term research plan in stealth technologies includes also the olfactory sense (e.g., by cooperation with the Monell Chemical Senses Center) and the use of vibrotactile interfaces (bone conduction and tactile) for stealth small unit communication. These additional research areas are not addressed in this report and will be the objects of separate reports.

7. Auditory Stealth Research

The goal of the initial phase of this research is to determine the feasibility and potential extent of intentional alterations of salient acoustic characteristics of the surrounding environment by a Soldier or operative in order to provide enhanced stealthiness of conducted operations. The key research questions are:

- How, when, and to what extent can the surrounding environment be manipulated without attracting the attention of the casual observer or an adversary?
- What are the acoustic technologies that can aid in suppressing the detection of physical presence, movement, and acoustic signatures of a person or an object?
- What are the technical challenges to stealth manipulation of the environment regarding the inconspicuous addition to and changing in level of environmental sounds?
- What are the benefits, limitations, and technical requirements for local acoustic decoys used to detract the casual observer or the adversary's attention?

The research activities are proposed to concentrate on three areas of interest:

1. Environment manipulation,
2. Environmental masking, and
3. Local (personal) acoustic decoys.

Environment manipulations using acoustic means may include time-limited increase in the level of existing environmental background, increase of the density of natural co-existing sound effects, use of reflected sounds for directional masking of conducted activity, and adding at a pre-selected time a time-limited non-existent sound that is natural in a given environment. All these manipulations are intended to help the users to blend their presence and activities as much as possible into the surrounding background. The success of environmental manipulation

techniques depends on effective exploitation of the *change deafness* phenomenon and the development of supporting technological means to introduce virtual natural sounds.

Environmental acoustic masking involves understanding and proper use of selected natural environments to mask intended activities. Environmental masking strategies may involve exploitation of various forms of informational masking (e.g., similarity masking and uncertainty masking) and manipulation of signal-probability density of the existing environment. It may also include an addition of unobtrusive masking sounds that naturally blend with a given operational environment (e.g., wind sound, aircraft sound). In some cases, the environmental manipulation techniques may be applied through a much longer time scale. It may be, expected that, in low signal-to-noise environments, the decisions made by the opposing forces may be, to some degree, based on expectations and beliefs rather than on the actual environmental data. However, such behavior needs to be still researched and documented. Some of the new technologies that may be successfully applied for masking or confusing purposes are audio spotlight (e.g., Yoneyama and Fujimoto, 1983; Anonymous, 1996; Pompei, 1999) and stereo-dipole (Kirkeby et al., 1996; 1997) technologies.

Local (personal) acoustic decoys are low-power, remotely-controlled, and visually-concealed devices that can produce a sound distracting the attention of enemy forces or a passer-by. Their role is to divert attention of the enemy forces or the passer-by from incidental discovery of the acting Soldier (operative) or a hidden object.

All three areas of interest require basic research studies to understand the psychology of *ad-hoc* sensory deception and to develop effective stealth operations techniques. In parallel, novel technical means need to be developed allowing almost real-time manipulation of the sonic environment; creation of sound effects using visually deceptive, remote-controlled, and programmable miniature sound effect generators; creation of acoustic holograms and phantom sound sources; and networked, proximity-triggered, miniature sound sources simulating sound source movement. Supporting technologies include, but are not limited to, multisensory virtual reality (e.g., enhanced VirtSim systems), acoustic signal processing, microelectronics, power generation technologies, and digital technologies.

8. Visual Stealth Research

The aim of the initial phase of this research is to create and capitalize on an annotated database of visual and behavioral deception techniques that Soldiers are currently using to protect and hide their presence and activities. This database will serve as a baseline in the development of new low-tech stealth technologies and as the source of inspiration for further potential enhancements using more advanced technologies. The database should include the means and behaviors long practiced by small, specialized units required to maneuver in and infiltrate hostile

or mixed territory, such as use of clothing and gear common in the area of interest or used by the adversaries, creating places of concealment along less-traveled roads, and adaptation of habits and practices displayed by the adversary and the local population. Some specific technology-oriented areas of research include:

1. Environment manipulation,
2. Visual masking, and
3. Dynamic holographic decoys and holographic environments.

Optical environment manipulation is focused on active camouflage systems. An active optical camouflage system, dubbed *invisible cloak*, employs sensor/transmitters in a form of small beads woven throughout the retro-reflective "meta-material fabric" worn by dismounted Soldiers (e.g., Smolyaninov et al., 2008; Tachi, 2003). These sensor/transmitters would take in ambient spectroscopic input and reproduce it rapidly and dynamically as Soldiers move through an environment. This is a visual analog of the auditory masking previously described. Power draw would optimally be low or be facilitated by solar cells also interwoven over the surface area of the fabric. The space occupied by power cells may detract from the quality of visual replication of the areas immediately surrounding the sensor/transmitters (i.e., presumably, they would appear as non-uniform or as environmentally non-representative incongruities across the surface of the clothing), but design may overcome this challenge depending on how small such cells can be made while remaining effective as energy transducers. Night operations would obviously benefit most from the proposed technologies, since less light would need to be manipulated in order to achieve natural masking, and thereby such environments would reduce likelihood of natural detection and reduce power draw. U.S. Army infantry and scout reconnaissance operations already largely employ darkness to tactical advantage when surveying and observing an area and would stand to benefit from such capability.

However, regardless of the active or passive camouflage technology, it is still not entirely clear what causes camouflage-breaking observations and detection of hidden objects. Visual maskers can differ is large number of aspects including pattern, color, size, shape, dynamics, curvature, structure, etc., which may or not fit well together. A better understanding of the mechanisms, such as edge detection, by which one recognizes or fails to recognize specific patterns, is still needed.

Holographic decoys are the future applications of holographic images that can be created as needed at a distance from the protected object or covert activity. The holographic decoy can, for example, represent a poorly hidden person who begins to move away and finally disappears when being approached. Similarly, special projection systems may project a benign picture or surrounding scenery on an invisible screen hiding an object or activity from being seen by a casual by-passer or adversary's scouts. In all cases, any new type of decoys or protection systems must be deployable in all potential operating environments of the U.S. Army.

The main initial challenges to the proposed sensory (i.e., auditory, visual, and olfactory) research are the need to develop new research paradigms allowing searching for unknown but suspicious activities and the development of metrics of success for hiding and displaying behaviors.

9. Research Goals: Time Frame

The research goals just presented have different levels of difficulty and complexity and can be divided into near- , mid-, and far-term goals. The proposed timeframe of the discussed auditory and visual research activities is outlined as follows.

Near-term Goals: Create an annotated database of visual and auditory deception techniques and related technologies that Soldiers are currently using to protect and hide their activities. Develop a testing methodology for investigation of audibility of environmental changes. Identify salient characteristics of selected environments suitable for manipulation. Determine the range of environment manipulations that can be made without attracting the attention of the casual observer or security forces. Investigate properties of selected static and dynamic environmental maskers. Develop effective meta-material screens (fabrics) reflecting the light in the direction of arrival. This needs to be addressed in the context of both the individual senses and multisensory perception.

Mid-term Goals: Develop a range of environmental maskers that can be used in selected environments under specific operational conditions. Develop and field-validate mission-relevant stealth manipulation techniques of the surrounding environment. Develop testing methodology for assessment of effectiveness and visual un-detectability of local acoustic decoys. Determine the basic properties and operational effectiveness of selected local acoustic decoys. Develop invisible projection systems creating visual masking surfaces.

Far-term Goals: Develop technical means to enable stealth manipulation of surrounding environment. Build prototypes of environmental manipulators. Develop and field test prototypes of selected local acoustic and visual decoys. Incorporate the effects of environment alteration in the extended versions of the Auditory Detection Model and Visual Detection Model. Develop action-dependent mobile holograms.

One important activity interwoven through all the stages of the proposed research program is the development of operational guidelines for various stealth behaviors and techniques. These guidelines need to be based on the to-be-developed metrics of the utility of various stealth actions under various programmatic and environmental conditions.

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