Description of document:	**Department of Energy (DOE) White Paper: Microbiotics for Non-Lethal Warfare, April 1994**
Requested date:	02-January-2008
Released date:	03-March-2008
Posted date:	09-June-2008
Title of Document	A White Paper for Microbiotics for Non-Lethal Warfare, April 1994
Date/date range of document:	1994
Source of document:	Freedom of Information Act (FOIA) Freedom of Information Act U.S. Department of Energy 1000 Independence Ave., S.W. Washington, DC 20585 Phone: (202) 586-5955 E-mail: FOIA-CENTRAL@hq.doe.gov Department of Energy National Nuclear Security Administration Service Center P. O. Box 5400 Albuquerque, NM 87185

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March 3, 2008

CERTIFIED MAIL – RESTRICTED DELIVERY – RETURN RECEIPT REQUESTED

This is in final response to your Freedom of Information Act (FOIA) request dated January 2, 2008 for a copy of information related to Microrobotic for Nonlethal Warfare.

Please reference Ms. Verlette L. Gatlin's letter to you dated January 2, 2008, in which she informed you that she was transferring your request to our office for review and direct release of a document that originated at the Los Alamos National Laboratory.

I contacted the Los Alamos Site Office (LASO) who has oversight responsibility for the Los Alamos National Laboratory (LANL). LASO forwarded the subject document to LANL for review and LANL determined the document was totally releasable to you. It is enclosed in its entirety.

There are no fees chargeable to you.

If you have questions concerning the processing of your request, please contact Ms. Shirley L. Peterson at (505) 845-6393 and reference Control Number FOIA 08-014-P.

Sincerely,

Carolyn A. Becknell
Freedom of Information Act Offaicer
Office of Public Affairs

Enclosure

Cc w/o enclosure:
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Cat 3

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Los Alamos
NATIONAL LABORATORY

A White Paper for

Microrobotics for Nonlethal Warfare

To be Performed by:

Los Alamos National Laboratory
Los Alamos, NM 87545
(under DOE contract W-7405-ENG-36)

Walter L. Kirchner
Program Director for Department of Defense Programs
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Los Alamos, NM 87545

April 1994

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Los Alamos
NATIONAL LABORATORY

I. Title

Microrobotics for Nonlethal Warfare

II. Type Effort

S&T, ACTD

III. Proposed by:

Los Alamos National Laboratory

IV. Capability Sought and Possible Uses

We will develop a microelectromechanical vehicle to perform intelligence gathering missions and to deliver tiny quantities of explosive or chemical reagents to vulnerable points in weapon systems.

V. Technical Description

Progress in the development of microlithographic techniques for fabrication of motors, pumps, flexors, and other actuators, as well as chemical, electromagnetic, and mechanical sensors, has stimulated much speculation about the application of such devices in warfare. One area of speculation and research has dealt with construction of small — nearly undetectable by dint of size — sensor packages and their use in collecting intelligence about troop movements and other activities within enemy territory. These nonmotile robots could be dispensed by a low-observable UAV and could be interrogated from time to time by the same aircraft, probably by using a laser on the UAV and modulated corner cube on the robot. A second area of speculation and research has dealt with construction of micro-robots capable of moving themselves. For an intelligence mission, the motile robot would avoid the use of an invasive aircraft, which might provoke an escalation of the situation.

The more interesting role for the motile robot is its use as an antimateriel weapon. Each robot could carry only a tiny quantity of explosive or chemical and would be little threat to personnel, even if the robots badly malfunctioned. The robots would be programmed to find their way to vulnerable components of machinery and invoke a malfunction with minimal collateral effect. An underlying premise is that these devices could be manufactured in large quantities and at low cost, much the way integrated circuits are manufactured today. High probability of mission success could be ensured by redundancy — the robots would be unleashed in swarms. The concept is natural for nonlethal warfare of the future, as the target is the enemy's equipment — not the soldier.

How far in the future is this technology and what do we know today? The most important consideration for the motile microrobot is the energetics of its locomotion. From some analysis of utility in conflict, it appears that the two most effective modes of travel are flying and jumping. The latter certainly seems bizarre at first blush, but jumping is a very real option. It has both energy efficiency and stealth. Here is a summary of energetic

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considerations developed during a conference at the RAND Corporation in December 1992. As a baseline design, we assume a rechargeable thin-film (5-μm) lithium battery using an amorphous V_2O_5 cathode (3.7 tp 1.5 V) with a specific energy of 444 WH · kg^{-1}. We further assume a microvehicle weight of 1 gm and a battery weight of 1/3 gm. Rough calculations indicate that a well-designed air vehicle could hover with a power consumption of 30 mW, or fly at an airspeed of 7 m · sec^{-1} with a power consumption of 45 mW. The hover endurance would therefore be 4.8 hr and the flight endurance would be 3.2 hr for a maximum range of 81 km. The air vehicle could fly 10 km and retain 88% of its energy for performing the other tasks of its mission. A jumping microvehicle would require 5 J to travel 1 km, so it could take a sequence of jumps to exhaustion in 105 km or jump 10 km with 90% of its energy remaining for other tasks.

The first phase of a development program would be a detailed theoretical design study for the microvehicle. The study would be directed toward constructing a prototype with attention to its eventual mass manufacture using microlithographic fabrication techniques. The first phase would be construction of a prototype with attention to its eventual mass manufacture using microlithographic fabrication techniques. The second phase would be construction and demonstration of the prototype vehicle and careful measurement of its performance characteristics. The third phase would be design and development of payloads for the microvehicle, whether they are intelligence gathering apparatus or electrical, mechanical, or chemical disrupters of various sorts. The fourth phase would be integration of one or more of the microrobotic systems.

VI. Risks and Limitations

The concept of microrobots in nonlethal warfare is exceedingly speculative. Although microlithographic techniques have made impressive progress, only crude electromechanical systems have been demonstrated. No fundamental scientific breakthroughs are required to make microrobotics a reality, but myriad technical details may make it impractical. The initial effort of the proposed program is to demonstrate a microvehicle capable of crossing distances of significance in military operations. Even if this task is accomplished, it will not be immediately clear that these vehicles can be manufactured cheaply nor that they can serve as an effective platform for micromunitions necessary to the proposed antimateriel mission. The exact nature of that mission is omitted in this proposal because it will be shaped by the performance of the vehicle. However, it is reasonable to assume that the "vulnerable" points of weapons systems could be protected from straight forward penetration. The intelligence-gathering mission is considerably more difficult to thwart.

VII. Project Plan

The present proposal is for a 3-year program (Phases 1 and 2) culminating in a prototype demonstration. To aid the planning process, we include projection for a follow-on integration and weaponization program (Phases 3 and 4). Assuming an October 1994 start.

Phase 1. Theoretical design study for microvehicle.
Completion October 1995.

Phase 2. Construction and demonstration of prototype vehicle and measurement of performance characteristics.
Completion October 1997.

Phase 3. Design and development of payloads for the microvehicle. Completion October 1999.

Phase 4. Integration of microrobotic system. Completion October 2000.

VIII. Project Cost by Fiscal Year

Phase 1 and 2: Prototype Demonstration
FY 1995: $1M
FY 1996: $2M
FY 1997: $3M

Phases 3 and 4: Integration
FY 1998: $3M
FY 1999: $3M
FY 2000: $3M

IX. Organization Point of Contact

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