SAND2000-2856C

RECEIVED
NOV 2 0 2000
OSTI

Emerging Technologies and MOUT

Gerold Yonas and Timothy Moy
Advanced Concepts Group
Sandia National Laboratories*

Operating in a potentially hostile city is every soldier's nightmare. The staggering complexity of the urban environment means that deadly threats—or non-combatants—may lurk behind every corner, doorway, or window. Urban operations present an almost unparalleled challenge to the modern professional military.

The complexity of urban operations is further amplified by the diversity of missions that the military will be called upon to conduct in urban terrain. Peace-making and peace-keeping missions, urban raids to seize airports or WMD sites or to rescue hostages, and extended urban combat operations all present different sorts of challenges for planners and troops on the ground.

Technology almost never serves as a magic bullet, and past predictions of technological miracles pile high on the ash heap of history. At the same time, it is a vital element of planning in the modern age to consider and, if possible, take advantage of emerging technologies. We believe that technologies can assist military operations in urbanized terrain (MOUT) in three primary areas.

The Need to Know

The intricacy of the urban environment, coupled with the complexity of urban operations (especially operations other than war), converge to create an enormous demand for precision awareness. This exquisitely high level of situational awareness will be necessary on several levels. Operational success may hinge upon knowing the precise location and disposition of time-critical targets (like WMD stores for example), or upon having an extremely detailed map of friendly forces, hostile forces, and non-combatants in a given city block.

In almost all of these cases, we can enhance the precision of our situational awareness through the use of electronic sensors. Acoustic, seismic, electro-magnetic and video sensors are now small and rugged enough that they can be deployed by various methods in large numbers and operate for extended periods with no human maintenance. The Steel Rattler, for example, is a hand-emplaced acoustic-seismic sensor with a thermal imager that can detect, classify, and identify time-critical mobile targets by their acoustic-seismic-thermal signatures. Steel Eagle is an airdropped version of the same package, and has already been fitted for deployment by the F-15, F-16, and F/A-18. Multi-function sensor packages of this sort could provide MOUT planners with precise data on the movement of forces and materiel, even in an environment as complex as a modern city.

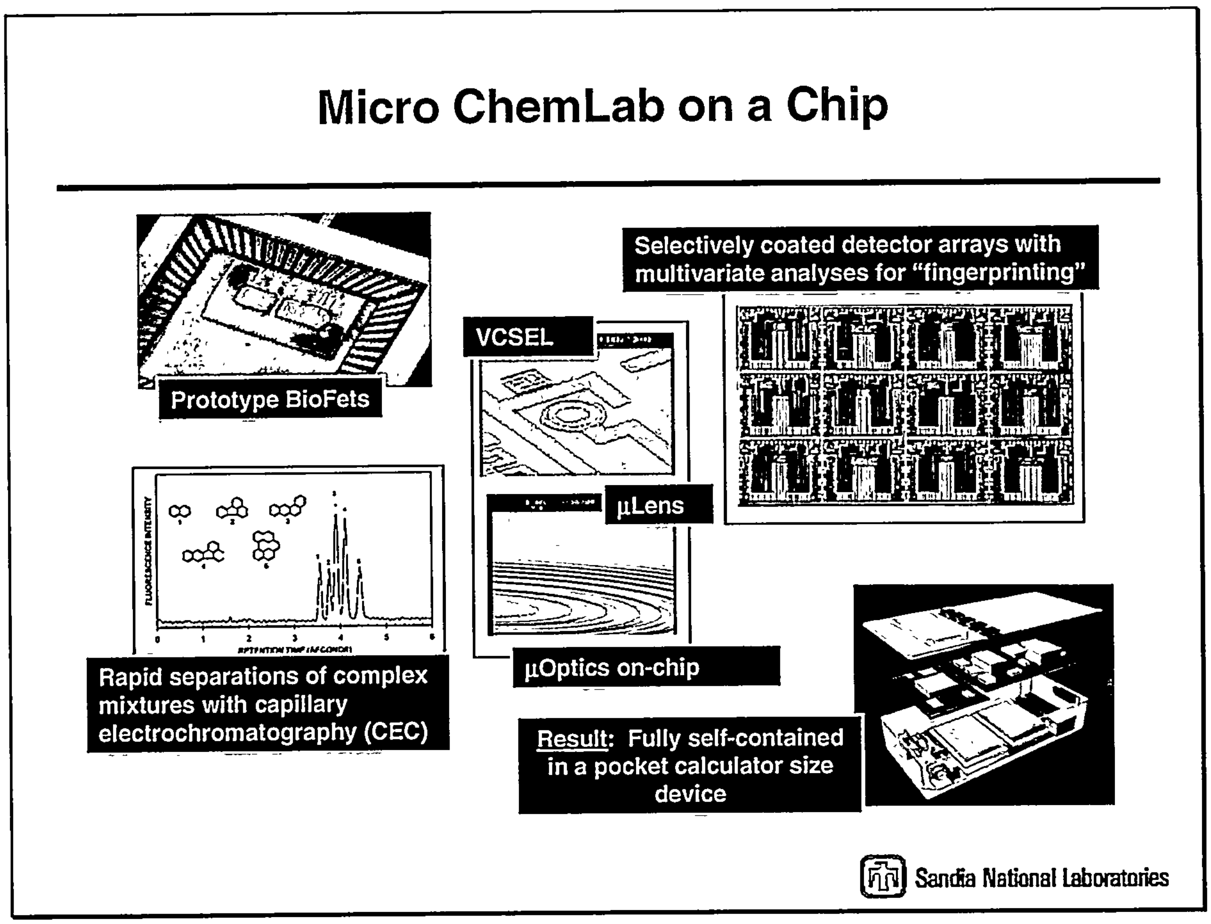
**Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000*

DISCLAIMER

DISCLAIMER

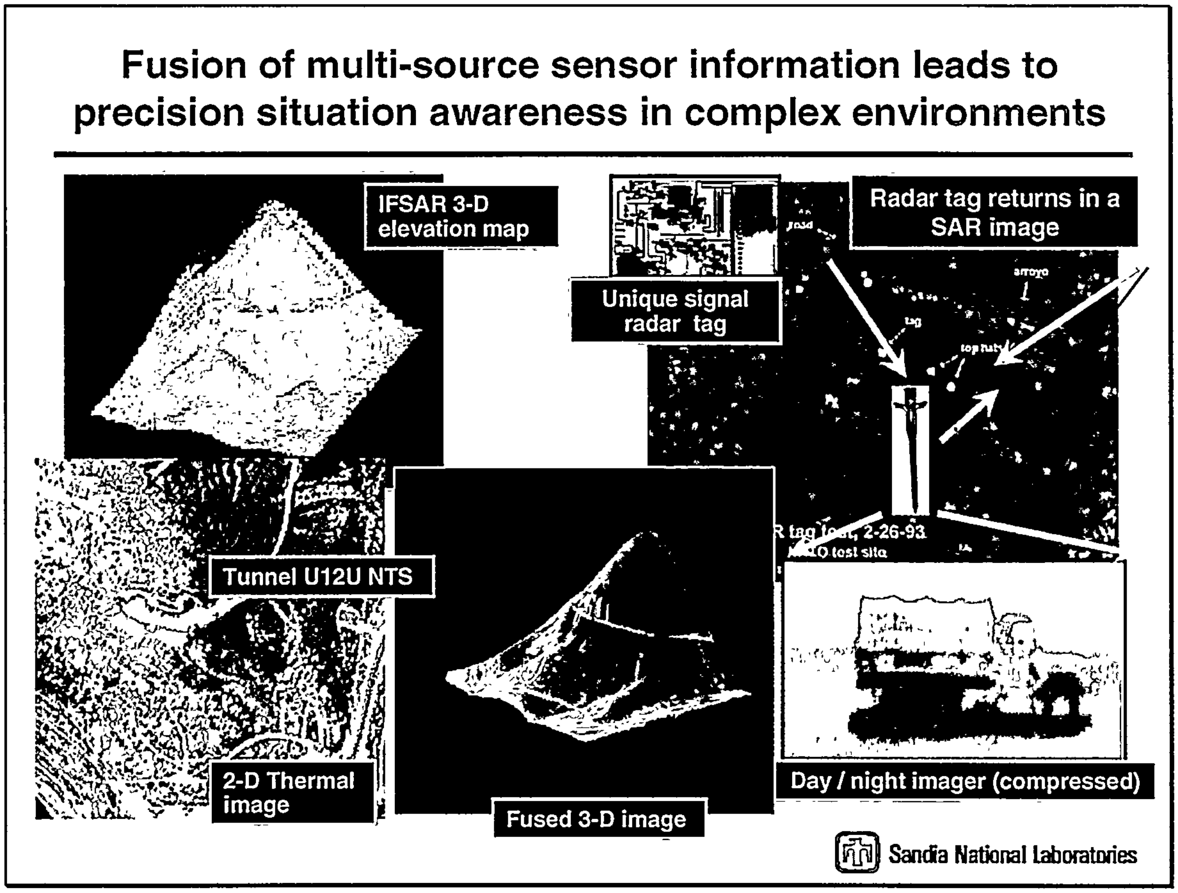
Further precision is on the horizon. Sandia National Laboratories conducted a multi-year initiative to develop a micro "chemlab on a chip." By applying a combination of detection methods in a single electronics package, Sandia has built a fully self-contained, pocket-sized device that could be useful in MOUT for detecting explosives or other substances that have identifiable chemical signatures (see Figure 1). Similar devices for local-area detection of biological weapons are in development, though this is a harder technical challenge; nevertheless, hand-held bio-weapon detectors should be available in the next five years. Eventually, MOUT forces will be able to take advantage of sensor fusion: the large-scale combination of varying sensor inputs to produce a single, coherent, and precise picture of the operational environment (see Figure 2).

(Figure 1)



One important technical challenge to precision awareness still remains. Complex sensor suites can acquire large amount of precise data, but data is not the same thing as knowledge. MOUT planners will benefit little from these sensor packages if they are not accompanied by improved techniques for processing the large amounts of data. This is a difficult problem, but one that we are also trying to address. Technology and techniques for transforming data into useful knowledge span the spectrum from analyzing complex models of human decision-making to designing relatively simple graphic interfaces that will allow human operators to interpret data more quickly and accurately.

(Figure 2)

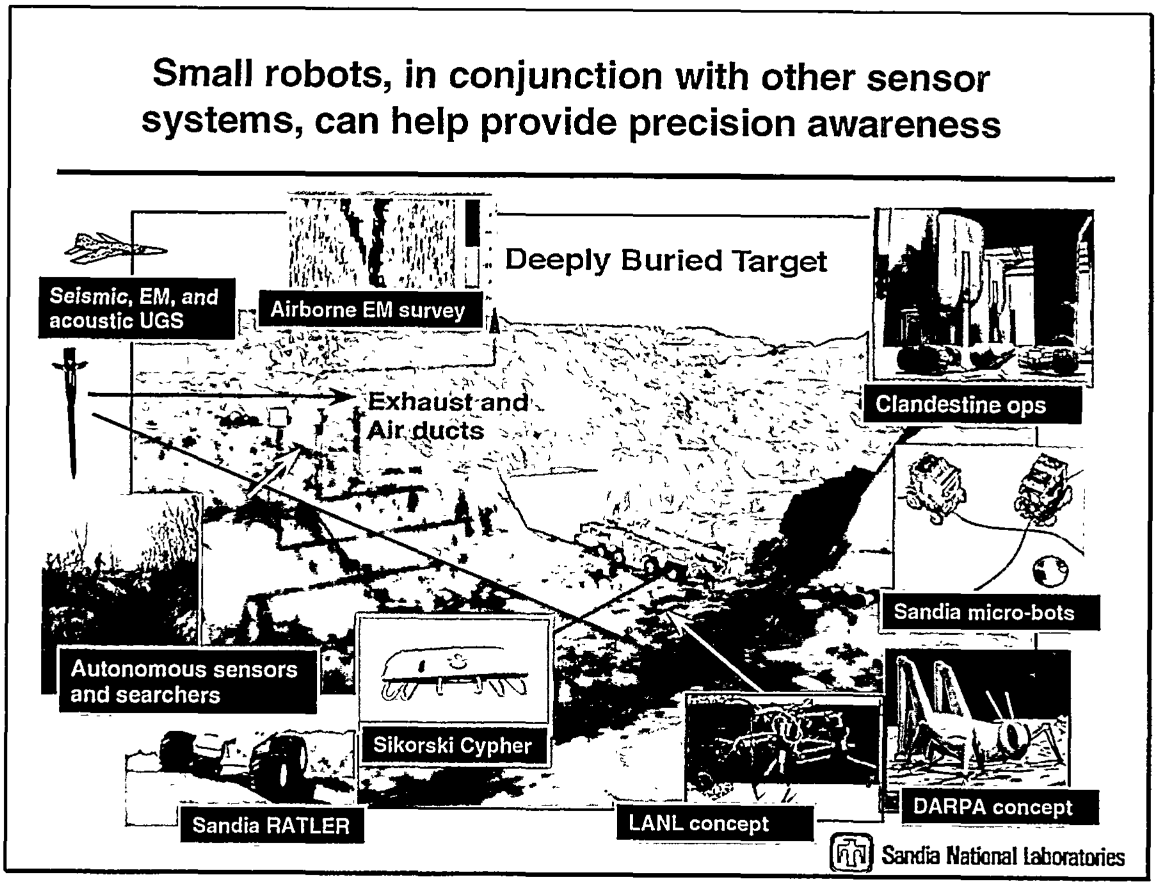


Going Mobile

One further twist on sensor technology leads into the second area of technological application: sensors can be mobile. The sensor suites described above could be combined with a GPS locator or radar tag, and then airdropped or otherwise deployed in large numbers to roam and reconnoiter an urban environment.

By this point, however, we are essentially talking about robots. Sandia has developed an array of mobile robots that can perform a variety of functions, many of which would be useful in urban operations. Relatively small and inexpensive robots can already carry sensor packages or even weapons. As these machines inexorably become smaller and less expensive, it will be possible to employ them in large numbers for clandestine reconnaissance and other operations in urban facilities (see Figure 3). This could be a particularly useful alternative to endangering personnel in high-risk situations, like scouting a possible chem/bio weapons release site.

(Figure 3)



The prospect of smaller, cheaper, and increasingly multi-function mobile robots raises yet another possibility that may be useful for MOUT planning. Computer simulations employing so-called genetic algorithms and agent-based modeling demonstrate that relatively simple machines can be engineered to learn from their experiences and evolve a surprisingly complex set of behaviors.

For example, researchers at Sandia have found that if very simple, virtual machines are programmed to perform a simple task (like, for example, finding an object in a room) and are also given some ability to alter their own programming, they will eventually begin cooperating and learning from each other even though they have not been programmed to do so. Large numbers of such virtual machines will thus exhibit something akin to swarming behavior, in which one machine's knowledge is quickly transmitted to and used by others in the group.

Consequently, it will almost certainly be possible to engineer large numbers of mobile robots to exhibit swarming behavior. This opens up a host of operational possibilities, the most obvious being for MOUT reconnaissance; large numbers of swarming robots could scout an area and sniff out a chemical weapons source, for example. As swarming intelligence improves, it may even be possible for robot swarms to identify positions and possible targets with little or no human intervention. This is clearly a technology still in development, but one that is worth considering for future MOUT doctrine.

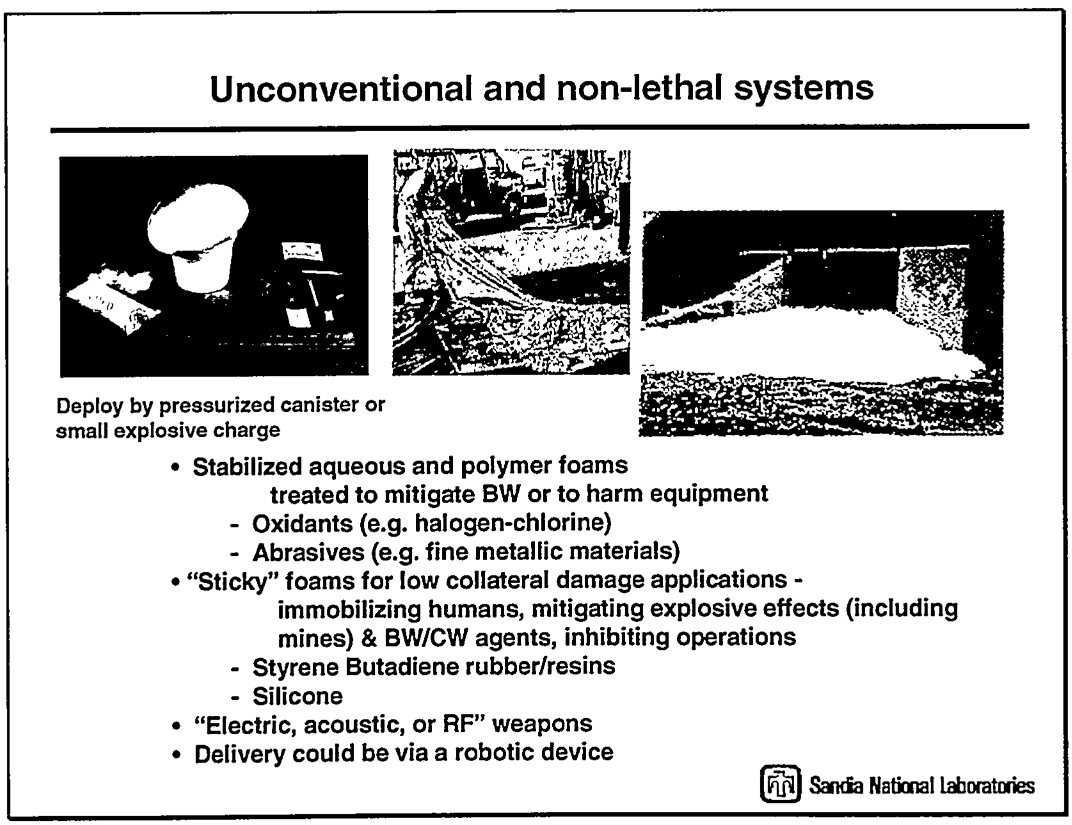
Half Tap

Just about all discussions of MOUT doctrine and procedures seem to turn eventually to the issue of non-combatant casualties. The conventional wisdom is that significant numbers of non-combatant casualties can have severe and deleterious consequences for American public support of a military campaign—an assessment that seems very plausible. While it will not serve as a magic bullet, emerging technologies may help address this problem as well.

Non-lethal weapons technologies are an obvious answer. Currently, many sub-lethal systems suffer from the fact that a weapon that is not lethal for a healthy, adult male may be quite lethal for an older person or a child. Sandia has been experimenting for many years with technologies that should not be lethal under any circumstances—"sticky foams," for example, that can immobilize machines or people without causing injury. In the near future, it will very likely be possible to design radio, acoustic, or optical weapons that incapacitate without injury (see Figure 4). Such technologies may not even require line-of-sight to target, and could thus be very useful for clearing rooms, buildings, and, eventually, entire city blocks. If it were deemed appropriate, such technologies could also be robot-deployed.

One difficulty with non-lethal technologies is the fact that they must obviously conform to the international treaties and conventions to which the United States subscribes. These conventions strictly regulate the use of non-conventional weapons and conduct regarding non-combatants. Non-lethal technologies, even ones specifically designed and employed to reduce non-combatant casualties, may be restricted under these conventions.

(Figure 4)



General Points

Whether or not the three areas of technological development discussed above turn out to be of use in MOUT planning and execution, they highlight three over-arching points that relate to technology, doctrine, and planning.

First, it will always be important to tailor the application of technology to specific missions by keeping the full spectrum of technological possibilities in mind. Differing mission parameters, rules of engagement, target sets, and so on will require the application of different sorts of technological systems. In this sense, there will be no single set of technologies for MOUT. Rather, there will be a host of technological systems that can be selectively tailored to various sorts of MOUT missions.

Second, our experience indicates that we should examine ways to streamline the pathway from development to deployment. Several of the technologies discussed in this essay were evaluated and approved for deployment several years ago, but have apparently not been employed in situations where they might have been extremely useful. At the conference at Ft. Knox, we showed a video clip of a mobile robot anti-tank weapon, and were gratified to receive a considerable amount of enthusiastic feedback; but this is a technology that has been available for some time. As the temporal window of technological superiority grows ever smaller, it will be increasingly important to bring emerging technologies to deployment as efficiently as possible.

Finally, while we need to guard against uncritical technological enthusiasm, we also need to be aware of the potentially revolutionary effects of new technologies. It is rare, but every once in a while a technology emerges that not only allows us to do what we used to do better, but also enables us to do things we simply could not do before. If operational doctrine is modified only with an eye toward revising previous doctrine, there will, almost by definition, be times when our forces will not be benefiting as fully as possible from the transforming capabilities of some technologies. Technology alone can never guarantee victory, but it can sometimes change the rules of the game. We should be ready to change along with it.