suggest that choosing the best (or the only) concept available at a given time and then engineering a package for experimentation has not been a successful approach. This failure is very likely due to the lack of continuity of basic research focused on the problem, which requires breakthrough solutions.

The relationship between this program and Army and Navy countermine exploratory development programs was not made clear, although the committee is generally aware of the limited success of the COBRA and the similar Airborne Stand-off Mine Detection System (ASTAMIDS) program and of ONR Code 32's efforts over the last year to cast a wider net for ideas and performers. Apparently, the scope of the JMDT program includes land and sea mines, buried, protruding above the bottom, and on the surface.

The JMDT program, as described to and understood by the committee, did not entail the systematic use of scientific methods expected of an ONR exploratory development program. There seemed little interest in understanding the phenomenon of detection. No data on the statistics of targets and clutter at various wavelengths were presented. The addition of a new wavelength for investigation was justified on the basis that it had not been tried before. Possible differences in performance under sunlight, diffused daylight, and laser illumination were not discussed. The failure to provide a stable test minefield severely limits the value of any particular test result in an apparently haphazard search.

Recommendations

The committee recommends that Code 32 be enlisted to ensure that the goals and approach of the JMDT program, if it continues, are coordinated with those of the Navy and Army programs. All three Services should cooperate in building and maintaining a stable test minefield to which various sensors can be brought.

Given that the intent of this program is to provide broad-area information on the likely locations of minefields in enemy territory, sensor requirements need to consider area coverage rates, false contact rates, and platform survivability in the flight profile required for optimized sensor performance.

ONR Code 353 should leverage other ONR efforts such as exploitation of satellite imagery in the LRS program and assess the degree to which LRS products can be used to cue JMDT-type sensor approaches.

ONR should seek advice on and assistance with instrumentation from other remote sensing organizations. Powerful airborne multispectral and hyperspectral sensors exist—for example, the Hyperspectral Digital Imagery Collection Experiment—and flights of these sensors over a controlled test minefield should produce a database that can be widely disseminated to multiple investigators, who can subsequently determine how much spatial and spectral resolution is needed for minefield detection. Development of prototypes for Marine Corps use can resume once this fundamental knowledge is gained.

The database can also be used by multiple investigators for refining detection algorithms to support timely information dissemination. The Navy Tactical Exploitation of National Capabilities (TENCAP) Office, which has demonstrated powerful multispectral and hyperspectral algorithms for detecting anomalies in clutter, should be consulted in this regard.

The need for a coordinated 6.1 program in the phenomenology for the remote detection of land mines is cited in Chapter 7 in "Recommendations for New Programs" (page 62). The committee recommends that a continuously funded 6.1 program be established. The program would include the categorization of all threat conditions and backgrounds for all mine deployments, e.g., shallow water, surf zone, soft beach, vegetated and barren dry land, and wetlands. In particular, the actual threat of mines deployed in the surf zone over time should be quantified and validated. This involves fusion of

B

Previous Training and Education Studies

During the 1990s, three major efforts were made by National Research Council committees to examine the role of science and technology in enhancing job performance and increasing human efficiency in the military services: the Navy Carrier-21 study,[1] the Army Star-21 study,[2] and the Technology for Future Naval Forces (TFNF) study.[3] Relevant findings and recommendations from these studies are reproduced here.

NAVY CARRIER-21 STUDY (1991)

The Carrier-21 study was the first of the three studies to deal with training and educational technology. Although the analysis focused on identifying emerging technologies that would affect future training aboard carriers, many of the findings and recommendations are relevant to on-shore jobs and units and directly to Marine Corps forces.

The Human Factors Technology Group of the Carrier-21 study stated that dependence on computer-based technologies would become as commonplace and essential as today's dependence on the telephone. Further, these technologies must be harnessed in the training arena in ways that would make training more accessible, convenient, relevant, inexpensive, and effective. The most important of these technologies and their relationship to critical functions is shown in Figure B.1.

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[1]Naval Studies Board, National Research Council. 1991. "The Task Group Report of the Human Factors Technology Group," *Future Aircraft Carrier Technology, Vol. II: Task Group Reports (U),* National Academy Press, Washington, D.C., pp. 445-568 (classified).

[2]Board on Army Science and Technology, National Research Council. 1994. *STAR-21: Personnel Systems. Strategic Technologies for the Army of the Twenty-first Century*, National Academy Press, Washington, D.C.

[3] Naval Studies Board, National Research Council. 1997. *Technology for the United States Navy and Marine Corps: 2000-2035, Becoming a 21st-Century Force, Vol. 4: Human Resources*, National Academy Press, Washington, D.C.

ARMY STAR-21 STUDY (1994)

In the second of the three studies, one facet of the effort focused on personnel systems in the Army. The Personnel System Panel of the Star-21 study stated that training would become increasingly important. As missions became more unpredictable, the soldier would have to understand capabilities rather than doctrine and the job would become more strenuous. At the same time, rapid technological change would require continued retraining of experienced personnel. New jobs would place considerable demands on training technologies, which would have to:

- Be cost-effective and quickly applicable to emergent problems;
- Enable personnel to perform successfully in increasingly complex tasks;
- Be adaptable to different abilities and aptitudes;
- Be developed for specific social skills needed for teamwork roles; and
- Consider the motivation of the individual(s) being trained.

In addition to using cognitive science techniques to construct systems that are specifically intended for training, the Army should make extensive use of simulation systems—deployed in the field—to maintain unit readiness. The simulations should be user-reprogrammable to allow for a wide variety of computer systems that can be used to present meaningful tasks in forms that support efficient learning. The development of instructional tasks in these systems can utilize the expertise of experienced soldiers. Problems are presented with varying levels of help, so that students with different learning capacities can be trained in individually tailored sessions.

Not all training problems are solved by these suggestions. The available scientific base is deficient on three important topics. There is an insufficient understanding of (1) the learning that occurs on a job and the kind of technology that can make this learning more efficient, (2) how social interactions among workers promote or inhibit learning, and (3) the ways in which training prepares people to become effective learners and contributing members of a working group.

The panel concluded that to achieve better job performance and more efficient training, science and technology must be applied to the design of equipment for job training and to the management of the soldier's career. Table B.1 shows how areas of performance enhancement relate to one another, to technology, and to system management technology.