

DEVELOPMENT OF SMARTTS TRAINING TECHNOLOGY

Dr. Thomas J. Hammell
Eclotech Associates, Incorporated, North Stonington, CT

LT Thomas Crosby
Naval Training Equipment Center, Orlando, FL

ABSTRACT

The Submarine Advanced Reactive Tactical Training System (SMARTTS) will be the "training subsystem" of the 21A Series Submarine Combat System Trainers. SMARTTS is the result of a series of research and development investigations directed by the U. S. Naval Training Equipment Center investigating the application of advanced training technology to submarine tactics training. SMARTTS is expected to greatly enhance the tactics training process by improving the quality and quantity of tactics training and by correcting current deficiencies of the tactics training system. The advanced training technology embodied under SMARTTS will present emerging concepts and capabilities that should be initially developed as an integral part of every simulator-based training system. The paper summarizes the SMARTTS program placing particular emphasis on the development of the SMARTTS characteristics as a result of a modified instructional systems development analysis. The SMARTTS characteristics, which are primarily implemented via software additions to the simulator programs, are applicable to virtually every simulator-based training system. SMARTTS will be a major addition to the Submarine Combat System Trainers; it represents a milestone in that it is a major subsystem, emphasizing advanced training technology as an integral part of the training device.

INTRODUCTION

The Submarine Advanced Reactive Tactical Training System (SMARTTS) is the training subsystem of the submarine tactics training device. SMARTTS has been specifically designed to provide training assistance features to the 21A series Submarine Combat Systems Trainers (SCSTs) and thereby enhance their training effectiveness. SMARTTS is designed to address individual and team training requirements for the SSN MK 117 fire control system and AN/BQQ-5 sonar, and the SSBN MK 113 Mod 9 fire control system and AN/BQQ-2 sonar. SMARTTS is a strap-on subsystem, the preprototype of which is currently being installed on the 21A41 SCST, Norfolk, Virginia. An evaluation of the training effectiveness of the 21A41A SCST (i.e., with SMARTTS) will be accomplished in the operational training setting immediately following completion of the preprototype installation.

BACKGROUND — DEVELOPMENT OF SUBMARINE TRAINING TECHNOLOGY

The U.S. Navy submarine forces are experiencing accelerated transition to significantly improved, although increasingly complex, weapons and tactical command and control systems for both SSNs and SSBNs. These technological advances are matched by expanding submarine mission roles and tasks in tactical and strategic warfare, and other classified operations. Enhanced operational performance of weapons, fire control, sonar, periscopes, electronic support measures, and other sensors, together with advanced ship characteristics, places heavy emphasis on

responsible tactical command and control. High speed digital data processing, coupled with computer analysis of multiple-sensor inputs requires highly developed operator visual and interpretive skills. These skills must be supported by the operator's ability to make complex tactical decisions. The number of personnel directly involved in command and control within the submarine's tactical decisionmaking processes has likewise increased with fleet introduction of new technologically advanced systems. These developments are placing increasing demands on submarine tactical and operational training to promote operational readiness.

The overall submarine tactics training system, whether providing formalized team training in shore-based attack centers or individual on-the-job training at sea, principally exists to support submarine force operational readiness. Submarine Combat Systems Trainers (SCSTs) for SSNs and SSBNs are located at all major submarine operational training centers. Simulation methodology and equipment retrofits provide the latest in onboard equipment developments for the SCSTs. Collectively, these SCSTs represent the primary component of the submarine tactical training system.

Tactics training presently satisfies a wide range of requirements, from the submarine officer basic, indoctrination, and advanced courses (SOBC, SOIC, and SOAC) through advanced levels in the prospective executive officer (PXO) and the submarine force commander's prospective commanding officer (PCO) courses. Training within these courses spans individual through team contexts. SCST utilization includes these formal shore-based courses, as well as support for ships in refresher and predeployment training. Advanced training technology to enhance the training process is required for these SCSTs.

Note: The authors are solely responsible for this paper; it does not represent U. S. government positions or policy.

Until recently, with the advent of digitally processed sonar (e.g., AN/BQQ-5) and fire control (i.e., MK 113 Mod 10 and MK 117) information and advanced weapons (e.g., MK 48 torpedo, Tomahawk), submarine tactics had changed little since World War II. This was generally true of both the hardware systems and the tactics employed in their use. Although some hardware changes did evolve, they were primarily the result of better hardware designs to perform the same functions. Several notable exceptions were the MK 51 analyzer and several plotting techniques (e.g., Eklund ranging) which were developed during this period. Nevertheless, those changes that did occur represented a steady evolution in submarine tactical capability. During this period, the Naval Training Device Center (NTDC) (which is currently the Naval Training Equipment Center — NTEC) had initiated a variety of research and development efforts investigating the improvement of training technology. With several notable exceptions, the majority of these efforts were concentrated on surface and aviation Navy training devices. Much of the early work investigating tactics training in the submarine force was performed in a series of NTDC/NTEC-studies by Sidorsky and others during the 1960s.^(1,2,3) Sidorsky's work centered on tactical decisionmaking, resulting in a decisionmaking taxonomy that has been the basis for several applications of decisionmaking theory in the operational environment. Hammell and Mara⁽⁴⁾ used the taxonomy as the basis of an approach to submarine tactical decisionmaking training. Observations on SCSTs, discussions with naval training and operational personnel, and analysis of at-sea exercise data indicated the potential of this approach to training. A later effort by Pesch, Hammell, and Ewalt,⁽⁵⁾ used the Sidorsky taxonomy as one level of a multileveled approach to submarine officer tactical decisionmaking training. This latter approach has been used successfully to train merchant ship masters in decisionmaking regarding the international rules-of-the-road.⁽⁶⁾

A second major development by Sidorsky was the TACTRAIN device, an individualized CRT-based tactical decisionmaking trainer. It was developed to train advanced tactical decisionmaking to senior submarine officers. TACTRAIN introduced several new concepts to the submarine training community. It provided individualized training to senior officers; it was based on a CRT driven by a computer in a war-gaming format; it enabled a wide range of flexibility in controlling the training process; and its model functioned on the basis of probability estimates (e.g., probability of counterdetection). At that time, however, the operational submarine fire control system (e.g., MK 113 Mod 6) did not deal with probability estimates or display such data on CRTs.

The submarine fire control systems in use during the mid-1960s were basically similar to the earlier fire control systems in function, although somewhat different in hardware layout. The Submarine School (SUBSCOL) in New London was charged with training officers entering the SOBC. The traditional approach had been to provide individualized training on the attack director, followed by team training on the SCST. A group of individual

torpedo data computers (MK 4) were used for individualized training with regard to the older basic submarine fire control systems (MK 106). Individual training devices, however, were not available for individualized training on the newer MK 75 attack director used in the MK 113 fire control system series. A request by SUBSCOL for a group of individualized MK 75 attack director trainers prompted NTDC to initiate an investigative effort to determine specific submarine officer requirements for tactics trainers. The intent was to approach the tactical training issue by systematically analyzing tactics training to determine the then current and future training device requirements. During the late 1960s, a variety of fundamental tactics and hardware changes were in the developmental stage (e.g., digital sonar hardware, digital fire control hardware, and MK 48 torpedo). These advances were to have a profound impact on submarine tactics.

The investigation, which initially considered basic level training and was later expanded to include advanced officer training and all SCSTs, identified a variety of areas in which the tactics training process could be improved.^(7,8) The identification of the need for a variety of individualized training devices together with the advanced knowledge of the computer/CRT-based fire control systems under development at that time, resulted in the recommendation for the Generalized Individual Trainer. The recommended Generalized Individual Trainer was to be a general purpose computer-based CRT console that could be readily configured to meet the wide variety of training needs; furthermore, this device could incorporate advanced training technology concepts. More importantly, these investigations found that the current SCSTs lacked fundamental training technology capabilities which had the potential of greatly enhancing the training process. The authors concluded that if these capabilities were incorporated into the training device when initially developed, they would represent a relatively small increase in cost. A variety of training-related capabilities were recommended to be installed on the existing SCSTs. These recommendations addressed three aspects of the training system: 1) trainee information; 2) instructor support, and 3) training system management. The SMARTTS characteristics represent the development and application of these earlier developed concepts.

Hammell et al.⁽⁹⁾ carried the investigation a step further by developing a performance measurement approach for submarine tactics training. The nature of the submarine tactical problem (i.e., decision-making) has precluded the development of complete standardized operating procedures, resulting in a difficult performance measurement task. The developed technique is based on the use of submarine system effectiveness models (e.g., weapon systems effectiveness models). The model would generate complex measures of overall system or subsystem effectiveness which could be related to specific trainee actions. Although the operational forces were still using the analog-based fire control systems at that time, tactical operations were beginning to undergo substantial changes, which would be conducive to the use of this performance measurement approach (e.g., use of sound wave ray path analysis during approach and

use of probability of counterdetection). These tactical changes coincided with the major new developments in sensors and fire control systems, such as the MK 81 weapon control console. These factors have led over the succeeding years to acceptance of the training concepts and capabilities that were to be embodied in SMARTTS.

The Naval Training Equipment Center took another step in the development of submarine tactics training capabilities by evaluating a laboratory version of the advanced training technology subsystem^(10,11) that embodied many of the recommended training assistance capabilities. A variety of Naval training and operations personnel from Submarine Forces, Pacific (SUBPAC); Submarine Training, Pacific (SUBTRAPAC); Submarine Forces, Atlantic (SUPLANT); SUBSCOL; and other groups reviewed the capabilities of the laboratory version and participated in experiments with it. The response was uniformly strong in approval of using the advanced training technology concepts.

Additional support for the advanced training technology concepts came from naval training personnel at the 21A40 SCST site. The limited training technology concepts incorporated into the development of the handbook for the 21A40 SCST resulted in requests by the staff for the upgrading of their trainer to include several of these capabilities. The Naval Personnel Research and Development Center (NPRDC) developed a limited experimental capability on the 21A40 for investigating the effectiveness and acceptance of several of the recommended training assistance technology capabilities. Results from the investigation by Callan, Kelly, and Nicotra⁽¹²⁾ of the operational training of submarine crews, showed increased training effectiveness as a result of the advanced training technology. Many of these concepts have been further incorporated into other training programs and devices (e.g., Sonar Operational Training and Assessment Program — SOTAP); these applications generally support the effectiveness of the advanced training technology concepts.

The advanced training technology concepts forming the training subsystem that should be integrated into the training device/simulator design were developed by a series of NTDC/NTEC investigations. The systematic applied development of the advanced training technology subsystem, however, remains to be undertaken. This is being accomplished via the SMARTTS program.

TACTICS TRAINING SYSTEM

The training system, in any area of application, is composed of several elements. Various specifications for these elements are available^(13,14). A somewhat simplified version of the training system, as shown in Figure 1, consists of four major elements. The training objectives, which comprise the first element, specifically define the goals for which the remainder of the training system should be designed in the most cost-effective manner. The training objectives are typically the result of an analysis of tasks, skills, knowledge, performance standards, and conditions under which the preceding should be attained.

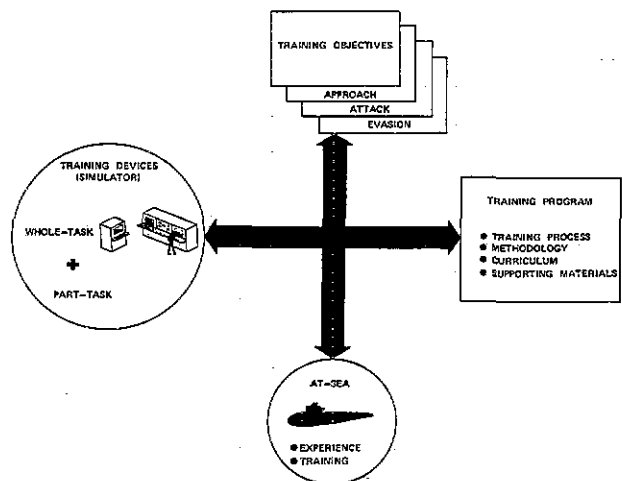


Figure 1. Elements of the Training System

The design characteristics for the remaining three elements of the training system should be determined on the basis of a trade-off analysis between each, so as to achieve the most cost-effective overall system design. The training program addresses the content of the training process as well as the methodology by which it is achieved. The materials to support the training process (e.g., instructor's guide, trainee handbook, and exercises) contain the training program. The training devices are tools to be used by the instructor as an aid in accomplishing the training objectives during the training program. The training system may have one or more training devices, including both part task and whole task trainers. On-the-job training, the final element represented in Figure 1, is an alternative to the training device in achieving certain of the training objectives. It is important that on-the-job training be investigated as a cost/effective means in trade-off with the training device.

Close integration between the design characteristics of the training device and training program is of primary importance to the achievement of a cost-effective training system design. The training device should be viewed as an aid to the conduct of the training program, in the achievement of the training objectives. To this end, the characteristics of the training device should be designed so as to aid the training program. This point is crucial; the training device should contain only those characteristics that most cost-effectively aid the training process. The modern training device, therefore, in the context of complex operational systems such as the submarine combat system, should have two major functions: 1) simulation of the operating environment and 2) training assistance (see Figure 2). The vast majority of simulator-based training devices in use today, by the military as well as commercial industry, do not adequately address the training problem. That is, they typically provide adequate simulation but provide little if any assistance to the conduct of the training process. The typical complex simulator/training device is computer based and has the capability to generate a wide variety of information relevant to the conduct of the training process, as well as provide much needed

TRAINING DEVICE

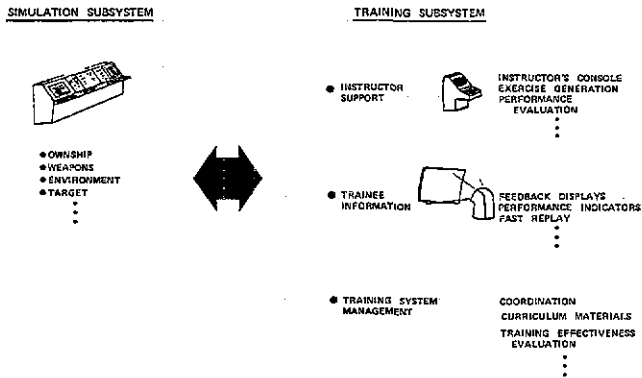


Figure 2. Major Subsystems of the Training Device and Their Functions

assistance to the instructor. This aspect of the training device has been grossly overlooked, although the basic capabilities may be readily developed to provide effective assistance to the trainees and instructor. SMARTTS directly addresses the training functions of the training device; it does not address the simulation function. SMARTTS keys on the training system concept, allocating to the instructor and other elements of the system those tasks for which they are most capable. For example, SMARTTS relieves the instructor from rudimentary tasks such as data recording, allowing him additional capacity to focus on more important tasks of the training process (e.g., monitoring trainee performance). Furthermore, SMARTTS capabilities supplement the instructor by generating needed information and providing control assistance which are typically beyond the capability of most instructors. Furthermore, the capabilities are designed to permit the evolution of the training system so as to be responsive to the constantly evolving operational and training needs. SMARTTS is a set of capabilities that represents the training function of the training device, in support of the training process.

SMARTTS DESCRIPTION

SMARTTS will be the first major subsystem of a simulator-based training device developed specifically to support the training function, rather than the simulation function of the training device. An extensive requirements analysis, therefore, was necessary. This analysis drew heavily from previous investigations to define the tasks of the various members of the fire control and sonar parties on the SSN and SSBN. The available information was updated as necessary to address the tasks to be performed in support of the MK 117 and MK 113 Mod 9 fire control systems, and the AN/BQQ-5 and AN/BQQ-2 sonar systems, and the utilization of recently developed weapon systems. The analysis also identified skill and knowledge requirements as well as performance criteria, measures, and standards, and identified the comprehensive set of training objectives across submarine tactics training. The functional characteristics for the SMARTTS were developed in consonance with these. Additionally, hardware and software design aspects of the potential

SMARTTS were analyzed during this analysis so as to delineate the potential costs of SMARTTS. The in-depth requirements analysis was necessary for SMARTTS since it represents the initial attempt to comprehensively define the training function of the training device. This represents a substantial change in philosophy regarding the design of the training device; that is, a change from simulator design to simulator plus training technology design. It, furthermore, represents the evolution of the training device from merely a support aid into a central integrating function directly impacting the design and conduct of many aspects of the training process.

SMARTTS provides the foundation upon which the integration of advanced training technology into the training device will have been developed and evaluated. Results of the test and evaluation phase of SMARTTS, in the operational environment, will complete the initial development. It will result in a catalog of demonstrated training technology concepts that can be integrated into other training devices in a wide range of applications. Subsequent applications of this training technology will require a considerably less extensive training requirements analysis since the concepts are generic in nature and may be readily tailored to many training applications. Rather, the development of a new training device would require an analysis only to identify the training objectives and to select from those SMARTTS characteristics that have already been developed. The selected characteristics would have to be tailored to the particular training application; this, however, would require considerably less effort.

SMARTTS will provide features to support three major aspects of the training process (see Figure 3): 1) trainee information, 2) instructor support, and 3) training system management. SMARTTS capabilities in each of these areas are summarized below.

Trainee Information

The importance of feedback information to the trainee regarding the outcome of his actions has been known for many years as an essential part of an effective training process. Relatively little in-

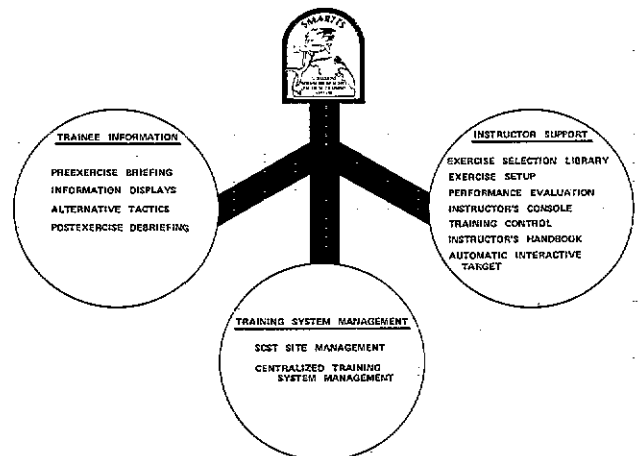


Figure 3. Major Support Areas of SMARTTS

formation is currently provided to the trainees prior to, during, or even after the training exercise on the SCST. The information that is provided to the trainee is generally a result of the instructor's observations, and is provided verbally immediately following the exercise. SMARTTS will provide capabilities to generate, store, and present performance-related information to the trainees. A wide variety of tactical and performance-related parameters will be computed during the exercise; these may also be computed prior to and following each exercise so as to discuss related points and alternative ownship actions. The generated parameters will be presented to the trainee on appropriately designed information displays (e.g., graphical, tabular summaries). SMARTTS will also provide the instructor with the capabilities to present the information in a variety of formats, tailored to the specific training problem. The information may be presented to the trainees on CRT monitors in the attack center (e.g., during a problem freeze) and on large screen displays in an adjoining classroom (i.e., prior to and/or following the simulator exercise). An example of a graphical display presenting several tactical performance indicators simultaneously is presented in Figure 4. The important aspect of these characteristics is that SMARTTS will provide the capability to generate and present the information. The particular performance indicators used, display formats, exercises, etc., will be tailored to the particular training problem; these are likely to evolve over time, changing to meet the changing training problem. SMARTTS will provide meaningful visual feedback to the trainee, enabling him to correlate his actions with relevant tactical parameters pertaining to his teammates, ownship disposition, and the target disposition. These characteristics represent the major area of SMARTTS concern. A summary of the specific characteristics follows:

- Preexercise briefing. A variety of capabilities will be available in a classroom context to assist the instructor in briefing the trainees prior to participating in the simulator-based exercises. The alternative tactics capability will enable fast-time gen-

eration of problems in the classroom, including the generation and display of performance indicators and other tactical parameters for a variety of ownship and target tactical actions. The classroom preexercise briefing sessions can be conducted while a different group is simultaneously participating in training on the simulator.

- Information displays. SMARTTS will generate a variety of performance indicators and relevant tactical parameters (e.g., probability of counterdetection). The information generated can be presented to the trainees on CRTs in the attack center and on a large screen display in the adjoining classroom. These displays will provide the means to present information for the preexercise briefing discussions, immediate feedback during the simulator exercise, and the postexercise debriefing discussions. The information so presented will enable the trainee to learn and understand the relationships between the various tactical parameters of interest as well as the impact of his actions and ownship's actions on the tactical problem. The displays will be under control of the instructor. A trainee entry device (i.e., a button) will be available at each operating station to permit flagging of tactical events during the exercise for later discussion.
- Alternative tactics. Alternative sets of ownship and target actions can be generated in fast-time during briefings to enable investigation of the relationships between relevant parameters (e.g., the impact of earlier ownship maneuvers; the impact of different ownship maneuvers on target motion analysis quality). These will assist training by enabling direct comparisons of performance indicators generated during the alternative actions.
- Postexercise debriefing. The postexercise debriefing is currently used in SCST training. The SMARTTS information generation, storage, and presentation capabilities will greatly enhance this process. Postexercise debriefing will be possible in the attack center using the SMARTTS CRT displays. Ideally, however, the debriefing sessions will be conducted in the classroom using the large screen display. The SMARTTS capabilities will enable the presentation of all relevant information concerning the just-completed exercise as well as the generation and investigation of alternative sets of tactics for the exercise situation and other situations. The capability will be present for the instructor and trainees to completely analyze the tactical problem, and focus on aspects of particular interest.

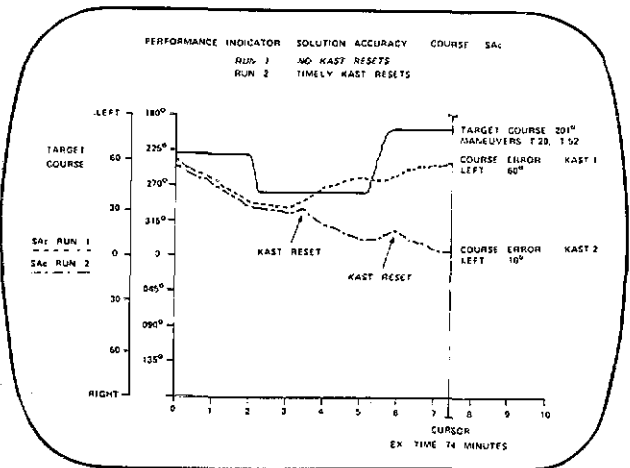


Figure 4. Example of Trainee Single Graph Feedback Display

Instructor Support

SMARTTS will greatly augment the currently limited instructor support facilities at each of the SCSTs. It will provide the instructor with additional capabilities to design and set up exercises, to control and monitor exercises while they are being conducted, and to provide more effective information to the trainees prior to, during, and

after each simulator exercise. Instructor support capabilities are summarized below:

- Exercise selection library. A library of highly structured prestored exercises will be available for selection by the instructor. Each exercise will be keyed to tactical and training objectives. The exercises will be highly structured allowing for necessary modification by the instructor either prior to or during their conduct on the simulator. Furthermore, the set of available exercises will be standardized across all SCST sites.
- Exercise setup. An off-line capability will be provided to enable the instructor to develop and evaluate exercises prior to their use in training. A remote terminal will be provided for this capability. The instructor will be able to develop the exercises, run them in fast-time, and investigate the results. He can designate appropriate performance indicators, training objectives, event cues, and so on, which will be prestored with the exercise. Furthermore, this capability will enable him to compare different exercises and readily modify them to achieve particular exercise design goals. Finally, the instructor will be able to add the new or modified exercise to the exercise library for permanent storage.
- Performance evaluation. A set of performance indicators will be available under SMARTTS. A subset of these indicators will be keyed to each exercise, achieving automatic generation and storage of the performance data during the exercise. The instructor may develop and store additional performance indicators as well as modify existing performance indicators. Furthermore, he can designate additional performance indicators for a particular exercise or remove existing performance indicators from an exercise. Cues will be provided, keyed to each exercise, to alert the instructor to particular predetermined observation requirements. The variety of performance indicators, and other tactical parameters will be available at an instructor's remote console for monitoring during the exercise. The information will be presented on a CRT display in an appropriate format (i.e., graphical, tabular, or some combination); additionally, selected parameters will be available for monitoring on an instructor's portable handheld remote console.
- Instructor's consoles. A remote semiportable console will be available for monitoring and control of the trainee exercise. It will consist of a CRT display, general purpose keyboard, and function keyboard. This semiportable device will be easily moveable to different locations in the attack center. It will enable the instructor to monitor and control from an attack center location while observing the trainees. A portable handheld display will also be available to enable the instructor to monitor selected parameters while moving about in the attack center. Ideally, this portable display will be wireless. The instructor displays will present information related to the performance

indicators, current tactical parameters, geographic track history, ownship status, training cues, instructional alerts, and alarm conditions.

- Training control. The instructor will have expanded capabilities to control the training exercise. These will include a freeze capability, projection of multiple ownship and target actions to evaluate their likely impact on the exercise, and analysis of trainee progress to assist in tailoring exercise selection and configuration.
- Instructors' handbook. A comprehensive instructor's handbook will be developed to assist in the development and conduct of an effective training process using the SMARTTS capabilities. The handbook will address the particular capabilities of SMARTTS as well as effective training practices. An instructor's course will be developed and administered to all instructors prior to their use of the SMARTTS system.
- Automatic interactive target. Currently, target actions on an SCST are either predetermined and canned, or controlled by the instructor. Target control by the instructor requires a considerable amount of time and often reflects the particular instructor's experiences rather than a representative set of target actions. The automatic interactive target (AIT) will provide for computer control of target actions, emulating in a probabilistic manner likely actions of the target, based on the best available intelligence information. The target will, in essence, react to ownship actions in concert with information provided via the environment, the target type, his mission, and the world situation.

Training System Management

The preceding two areas of SMARTTS primarily addressed conduct of the training process. The training system management capabilities of SMARTTS address the long-term structure and functioning of the training system and the training process. It provides for both intrasite and intersite management of the training process. Specific capabilities are as follows:

- Standardized curriculum materials. SMARTTS characteristics and other materials provided along with SMARTTS will be standardized across all SCST sites. These will include instructor and trainee handbooks, the exercise library, the SMARTTS system operator's manual, and an integrated curriculum across sites.
- SCST site management. The tactics training curriculum will be standardized across SCST sites, appropriate to the level of trainees and other factors being addressed at each site. Each site will participate in the development of the curriculum; each site will, furthermore, have the capability to tailor the curriculum to meet specific local needs. Changes in tactical doctrine would be quickly implemented by a centralized activity, resulting in a reduced administrative

burden at each site. Instructor training will be standardized for SMARTTS across sites. Finally, various training methods will be recommended singly and in combination for use with various exercises; this will further standardize the training methodology employed across sites.

- Centralized tactics training system management. A training management structure has been identified to configure and control the training process across SCST sites. This structure would come under the force commander's direction and would provide more unified and controlled curriculum, procedures, and performance criteria. This structure would act as the coordinating body across all SCST sites. Furthermore, the effectiveness of training at each site, the effectiveness of the various training methods being employed, the exercises being used, etc., would be monitored by this central activity, providing for a long-term analysis of the system's training effectiveness and the training needs.

SMARTTS DEVELOPMENT

The above discussion addresses the three major areas of SMARTTS, and summarizes characteristics of each area. These characteristics, which are explicitly identified in the SMARTTS Type "A" Specification,⁽¹⁵⁾ pertain to the eventual production SMARTTS. A preprototype version of SMARTTS is currently being developed and installed on the 21A41 SCST at Norfolk, Virginia. This preprototype will incorporate the essential features of SMARTTS, although not all of the specific characteristics. It should be noted that the essence of SMARTTS is the general computer-based capabilities denoted by the three major areas; the specific characteristics under each of these areas are likely to evolve as SMARTTS is used, with changing operational problems, changing training needs, and developing training technology. The SMARTTS capabilities will enable this evolution of characteristics to occur.

The preprototype installation on the 21A41 SCST will enable the evaluation of SMARTTS in the operational training setting. Information is presently being collected at the 21A41 SCST and other SCST sites regarding the instructor functions, training methodologies employed, and tactical team performance prior to and following training sessions. These data collected from traditionally-trained groups will comprise the control group data base for comparison with the SMARTTS-trained groups after the preprototype installation becomes operational. The collection of SMARTTS training data, as well as the subsequent evaluation of the training effectiveness of SMARTTS, will be conducted by an independent group. The purpose of this investigation will be two-fold: 1) to evaluate the effectiveness of groups trained using the SMARTTS technology with traditionally trained groups, and 2) to evaluate and improve the training effectiveness of the various characteristics of SMARTTS. It is expected that although SMARTTS will prove to be a cost-effective adjunct to the simulator/training device, its relatively large number of characteristics will have differing degrees of training effectiveness. Furthermore, it is expected that these characteristics will be improved over time and will be supplemented by additional SMARTTS characteris-

tics as appropriate to enhance the training process. It is the intent, therefore, that the SMARTTS evaluation also generate information relevant to the improvement/evolution of the various SMARTTS characteristics.

SMARTTS is a training subsystem specifically designed to meet requirements for the tactics training of submarine officers. The training technology concepts identified and developed, however, embody considerable generic aspects. Hence, they are likely to be directly applicable to most simulator-based training systems. It is likely that SMARTTS-type capabilities should be resident on many major computer controlled training devices. Specific characteristics, such as particular performance indicators and display formats, necessarily have to be tailored to each particular training application. Nevertheless, the generic capabilities represented by SMARTTS are potentially applicable to substantially impact the effectiveness in a wide range of training areas. For example, the SMARTTS technology has been applied and investigated for application in commercial deck officer training on ship bridge/shiphandling simulators; preliminary results indicate that this type of technology would substantially impact the effectiveness of those training devices. As an order of magnitude estimate, the SMARTTS capabilities, if developed and designed into the training device when initially procured, would cost about 20 percent of the device cost. Since the characteristics are predominantly implemented in software, relatively minor additional cost increments would be required for additional production units.

The training device, albeit a simulator, has often been developed independently of the other elements in the training system. The potentially extensive training assistance capabilities of the training device/simulator when configured to provide the SMARTTS-type training technology, necessitate close integration with the other elements of the training system so as to achieve the most effective design. Whereas the training systems design approach (e.g., Instructional Systems Development approach has often been ignored in the past, the potential training effectiveness gains to be achieved by incorporating the SMARTTS-type technology make the systems approach mandatory. The training device should not be independently developed; rather, it must be developed and closely integrated with the training program to meet the specific training objectives.

REFERENCES

1. R. C. Sidorsky and J. Houseman. Research on Generalized Skills Tactical Decisionmaking. Port Washington, New York: Naval Training Device Center. NAVTRADEVEN 1329-2, December 1966.
2. R. C. Sidorsky, J. Houseman, and D. E. Ferguson. Behavioral and Operational Aspects of Tactical Decisionmaking in AAW and ASW. Port Washington, New York: Naval Training Device Center. NAVTRADEVEN 1329-1, August 1964.
3. R. C. Sidorsky and T. D. Mara. Training Aspects of Computer-Aided Decisionmaking: Comparison of Two Approaches of Man-Computer Interaction. Or-

REFERENCES

- Iando, Florida: Naval Training Device Center. NAVTRADEVCCEN 1329-3, July 1968.
4. T. J. Hammell and T. D. Mara. Final Report - An Application of Decisionmaking and Team Training Research to Operational Training: A Translative Technique. Port Washington, New York: Naval Training Device Center. NAVTRADEVCCEN 68-C-0242-1, 1970.
 5. A. J. Pesch, T. J. Hammell, and F. M. Ewalt. Tactical Decisionmaking Training System Design. Orlando, Florida: Naval Training Equipment Center. NAVTRAEQUIPCEN 73-C-0158-1, November 1974.
 6. P. Aranow, T. J. Hammell, and M. Pollack. Rules of the Road Training Investigation. King's Point, New York: National Maritime Research Center. Report CAORF-103, 1977.
 7. T. J. Hammell, F. P. Sroka, and F. L. Allen. A Study of Training Device Needs for Meeting Basic Officer Tactics Training Requirements. Orlando, Florida: Naval Training Equipment Center. NAVTRAEQUIPCEN 69-C-0140-1, March 1971.
 8. T. J. Hammell, C. E. Gasteyer, and A. J. Pesch. Advanced Officer Tactics Training Device Needs and Performance Measurement Technique. Groton, Connecticut: General Dynamics, Electric Boat Division. NAVTRADEVCCEN 72-C-0053-1, Volume I, 1973.
 9. Ibid.
 10. A. J. Pesch, T. J. Hammell, and F. M. Ewalt. Tactical Decisionmaking Training System Design. Orlando, Florida: Naval Training Equipment Center. NAVTRAEQUIPCEN 73-C-0158-1, November 1974.
 11. T. J. Hammell, A. J. Pesch, F. M. Ewalt, and P. L. Rabe. Prototype Tactical Decisionmaking System - Device Summary. Orlando, Florida: Naval Training Equipment Center. NAVTRAEQUIPCEN 75-C-0078-1, February 1976.
 12. J. R. Callan, R. T. Kelly, and A. Nicotra. Measuring Submarine Approach Officer Performance on the 21A40 Trainer: Instrumentation and Preliminary Results. Naval Personnel Research and Development Center. NPRDC TR 78-9, 1978.
 13. G. G. Jeantheau. Handbook for Training Systems Evaluation. Orlando, Florida: Naval Training Device Center. NAVTRADEVCCEN 66-C-0013-1, November 1970.
 14. A. S. Blaiwes, J. A. Puig, and J. J. Regan. "Transfer of Training and the Measurement of Training Effectiveness," Human Factors, 1973 (15) (6), 525-533.
 15. T. J. Hammell, F. M. Ewalt, M. Hayes, and W. O. Henry. Submarine Advanced Reactive Tactical Training System Type "A" Specification. Orlando, Florida: Naval Training Equipment Center. NAVTRAEQUIPCEN 79-C-0029-A1, February 1980.

ABOUT THE AUTHORS

Dr. Thomas J. Hammell, Director of Research, Eclectech Associates, Incorporated, North Stonington, Connecticut.

LT Thomas N. Crosby, Aerospace Experimental Psychologist, Medical Service Corps, United States Navy Reserve, Naval Training Equipment Center, Code N-71, Orlando, Florida.