SUMMARY

BACKGROUND

Navy surface force training has traditionally involved a combination of shore-based and underway training. Recently, however, a number of factors—budgetary, political, and environmental concerns, as well as concerns about quality of life for naval personnel—have prompted Navy training officials to consider reducing underway training time and increasing reliance on shore-based simulators. Current personnel practices, such as rotating crews rather than ships to forward-deployed locations, also suggest that requiring crews to complete their training on the ships on which they will be deployed may be impractical. Finally, technological advances have improved productivity and realism in modeling, simulation, and distributed learning. These considerations have given rise to questions about whether relying more heavily on diverse kinds of simulation can decrease underway training and thereby reduce costs but still maintain or improve proficiency and readiness.

RESEARCH OBJECTIVE AND APPROACH

This research was undertaken to assess the potential of reducing or augmenting underway training by completing more training exercises through simulation. We focused, in particular, on live simulation and virtual, shore-based simulation.

In *live simulation*, a real person operates real equipment, but some aspect of the environment is simulated. Such exercises are carried out on the ship's own equipment—either in port or under way—and are credited toward its readiness rating as specified in the *Surface*

Force Training Manual (SURFTRAMAN). Reducing underway time through live simulation would simply involve increasing the proportion of such exercises conducted in port.

In *virtual simulation*, real people operate simulated systems. Reducing underway time through virtual simulation would involve completing more training in shore-based simulators designed specifically for this purpose. Currently, exercises completed through virtual simulation do not count toward a ship's readiness rating, indicating that using simulation to reduce underway time would, ultimately, require changes not only in training procedures but also in training policy.

In this report, we describe

- how simulation and simulators are used for U.S. Navy training for the DDG-51 class ship
- the use of simulation in other military organizations, in civilian aviation, and in commercial shipping
- the relationship between training exercises and the location in which they are conducted
- strategies for increasing the proportion of training exercises completed in port.

CURRENT SIMULATION POLICIES AND PRACTICES

Currently, the development, governance, financing, and use of simulation is a complex web, with multiple agencies responsible for defining and implementing modeling and simulation (M&S) policy. Furthermore, beyond the basic phase of training, training requirements for ships are only minimally articulated. The vagueness and inconsistency of training requirements and standards for assessing readiness further complicate the problem of determining how simulation might best be used. It would appear that successful use of simulation requires, at a minimum, integrated policy, planning, oversight, management, and adequate resources, as well as a good understanding of benefits and costs. Our review indicates that all these elements are missing, and the subsequent portions of our analysis attempt to provide a part of the empirical foundation needed for more rational policymaking in this domain.

DDG-51 CLASS TRAINING

The DDG-51 class guided missile destroyer operates offensively in a high density, multithreat environment as a member of a battle group, surface action group, amphibious task force, or underway replenishment group. For this class of ship, the SURFTRAMAN specifies 271 training exercises across 15 mission areas, about 85 percent of which must be repeated at least once within an annual cycle to maintain M-1 training readiness.

By the end of its basic training phase, a ship must have completed 80 percent of these exercises, be proficient (M-2) in all mission areas, have demonstrated the ability to sustain that readiness through its training team organization, and have successfully completed the Final Evaluation Period (FEP) readiness assessment. Subsequently, the ship completes intermediate and advanced training exercises as it prepares to deploy.

Only 58 (21 percent) of the 271 required exercises have approved equivalencies, meaning that credit toward readiness ratings can be earned by completing these exercises either under way or in port. Equivalencies have been approved for exercises in only six mission areas, all of which are tactical. There are no approved equivalencies for exercises in nontactical mission areas.

About one-third of the exercises with the longest time between repetitions (24 months) can currently be simulated, but only about one-tenth of the shortest exercises (three months or less) can be. These findings suggest that simulation has not been applied in the areas that could yield the greatest cost reductions. Because one of the benefits of simulation is being able to repeat training at low cost, it appears that simulation could be most efficiently applied to the exercises that are repeated most often.

In addition, a review of the simulators that can be used for exercises with approved equivalencies for the DDG-51 class, as well as those that are used for all other ships, indicated that a number of simulators support the same exercise. For about 85 percent of exercises that can be simulated, five or more simulators are available for each exercise. This observation suggests that the Navy training community has chosen to simulate better what can already be simulated rather than to explore the application of simulation to different exercises.

USE OF SIMULATORS IN OTHER ORGANIZATIONS

To determine what issues might arise in efforts to increase the use of simulation for training in the U.S. surface force, we examined how simulation is used and managed in other military and civilian organizations.

In the aviation community, which uses simulators extensively for training, experience indicates that their value depends, among other things, on task characteristics. For instance, a relatively small proportion of training exercises for fighter strike missions is conducted in simulators. For maritime patrol aircraft (MPA), however, about 50 percent of both basic flight and mission training exercises are completed in simulators. In commercial aviation, nearly all training is completed in simulators.

The Canadian Navy requires underway training for only the most advanced exercises—those that involve multiple ships. For all other exercises, the use of simulation is both permitted and encouraged. Among the uses of simulators in the Canadian Navy are familiarizing engineering personnel with machinery control systems, teaching maintenance procedures and ship-handling skills, and training radar navigation teams to use radar displays without the aid of visual references.

In some cases, the simulators the Canadian Navy uses were built as part of the procurement contract for the ships, which permits further cost reductions by integrating simulation in the design of the ship and in plans for training. Some simulators are aboard ships, but others are located at fixed sites, with personnel traveling to them for training. That training can be completed satisfactorily using shore-based simulators at fixed sites indicates that training on a ship's own equipment may be unnecessary for many exercises.

Like the Canadian Navy, the British Royal Navy uses simulation to reduce the costs and risks of training. Underway time is reserved for training in primary warfare mission areas. The Royal Navy has a navigation and ship-handling simulator, as well as a Combat Information Center (CIC) mockup for every class of ship. For Type 22 and 23 ships, the Royal Navy uses these trainers for new officers and also brings CIC teams from existing ships to HMS *Dryad*, one of the Royal Navy 's largest training facilities, to run tactical exercises as a prerequisite for operational sea training at Devonport. Operational sea

training is used as a postrepair period and providing the Royal Navy's readiness certification process. The combat system suites on the Type 22, 23, and 45 ships all have a simulation or training mode.

In commercial shipping, the International Convention on Standards of Training, Certification and Watchkeeping (STCW) for Seafarers establishes minimum requirements for personnel in certain areas of responsibility, as well as more-general requirements for all crew members, and permits these qualifying tasks to be performed on appropriate simulators. Training officials at the Maritime Institute of Technology and Graduate Studies (MITAGS) indicated that the simulators allow everyone to be trained in a timely manner through a core set of drills. In addition, simulators allow personnel to experience the casualty control exercises and procedures not normally done at sea, thereby preventing equipment damage and personnel injury.

Taken together, these observations indicate that simulation can be and is used effectively to provide many different kinds of training in military and civilian organizations whose needs are comparable to those of the U.S. surface force.

U.S. NAVY PERSPECTIVES ON SIMULATION

The Navy training representatives we interviewed acknowledged the potential value of using simulation to reduce underway time in surface force training, but they disagreed on how best to use it. Commander, Naval Surface Force, Atlantic (COMNAVSURFLANT) representatives indicated that underway training time could be reduced by completing more intermediate and advanced training in port. Commander Second Fleet (COMSECONDFLT) representatives, on the other hand, suggested that efforts to reduce underway time should focus on basic training. These representatives indicated that, for advanced and intermediate training, ships need to get under way. Although recognizing its potential value, these training officials were concerned that increasing the use of simulation might reduce professional competence, but they did not specify metrics for assessing professional competence, regardless of training method.

In addition to uncertainty about where simulation might be used most fruitfully and general skepticism about assessing its value, there are a number of more-specific factors that might interfere with im-

proved or increased use of simulation. In terms of naval policy, the most important of these factors may be the requirement that any exercise for which completion credit is claimed must be performed on a ship's own systems, i.e., completed through live simulation. This requirement precludes earning "readiness and training" credit for exercises completed in shore-based simulators. To take full advantage of the capabilities of current simulation technology, this requirement would need to be modified.

Another limiting factor that naval officers acknowledged was bias toward completing training exercises under way. A change in Navy culture may be required to achieve a higher level of in-port training involving simulated exercises. Other constraints include the cost of simulators, competing demands on in-port time, and the need to be under way to support other fleet training requirements.

Despite these obstacles, substantial efforts to increase the use of simulation in surface force training have been launched. For instance, COMSECONDFLT was tasked with making in-port integrated warfare training a reality and a standard requirement for battle group interdeployment training. The Battle Group In-Port Exercises (BGIE), with a trial phase conducted from January 2002 through spring 2003, will be conducted as part of BG Interdeployment Training Cycle training. As of this writing, it had not yet been determined whether these exercises will be added to underway exercises or whether they will replace underway training requirements. However, it appears that the Navy has increased its emphasis on in-port training. Further progress in this direction will require not only addressing the concerns noted above but also a detailed understanding of which exercises are now carried out in port and which under way as a basis for identifying exercises for which simulation would be most practical and beneficial.

WHERE DDG-51 TRAINING EXERCISES ARE COMPLETED NOW

In terms of possible completion sites, there are three classes of DDG-51 training exercises:

- exercises with equivalencies
- exercises with no equivalencies that can be completed under way or in port

- exercises with no equivalencies that can only be completed under way.

To assess the relationship between where exercises *could* be completed and where they *were* completed, we conducted a detailed quantitative analysis relying on four kinds of information: the locations of ships on specific dates during the period under study; the exercises that were completed and the dates on which they were completed; whether or not each of the completed exercises had an approved equivalency; and whether, in the views of Naval Surface Force, Atlantic (SURFLANT) training officials, exercises with no equivalencies could be completed under way or in port or could only be completed under way.

Table S.1 summarizes this analysis. Of the 8,250 exercises completed by nondeployed ships, 6,356 exercises (77 percent) were completed under way, and 1,894 (23 percent) were completed in port. Of exercises with equivalencies, all of which could be completed in port, 80 percent were completed under way. Only 20 percent were reported as having been completed in port. Thus, the existence of an approved equivalency did not affect the likelihood that an exercise would be completed under way. Neither did mission area appear to determine whether these exercises are completed in port or under way. Most exercises with equivalencies were completed under way, regardless of mission area. Further, a large majority (71 percent) of

Table S.1

All Exercises Were Completed

	Exercised Completed	
Exercise Type	Under Way (%)	In Port (%)
All exercises[a]	77	23
Exercises with equivalencies	80	20
Exercises that could be completed under way or in port	71	29
Exercises that could only be completed under way	92	8

[a]All figures for nondeployed ships only. For deployed ships, 99 percent of all exercises were completed under way.

the exercises that could, according to SURFLANT training officials, be completed under way or in port were also completed under way. Only 29 percent were completed in port.

Table S.1 also indicates that 8 percent of "underway only" exercises were completed in port. This finding may be a result of reporting error, or it may suggest that exercises that were categorized as "must be completed under way" are, in fact, sometimes completed in port.

Table S.2 summarizes the results of our analyses for exercises that could be completed in port that actually were completed in port. The data in the first column reflect 6,756 potential in-port exercises completed during the period we examined. Of these, 21 percent had equivalencies, and 79 percent were exercises that did not have equivalencies but that could have been completed either under way or in port. The second column shows the percentage of each type of potential in-port exercise that actually was completed in port. Exercises with equivalencies actually completed in port constitute 4 percent of exercises that could have been completed in port; exercises with no equivalencies that could be completed either in port or under way and were actually completed in port constitute 22 percent of potential in-port exercises. In sum, only 26 percent of all potential in-port exercises were actually completed in port—about one-fourth of the exercises that could have been completed in port. These data clearly indicate that there is substantial opportunity for increasing the proportion of training exercises conducted in port and, by extension, for increasing the use of simulation in training.

Table S.2

Proportion of All Exercises That Could Be Completed in Port Actually Completed in Port

	Exercises That Could Be Completed in Port	
Exercise Type	Possible (%)	Actual (%)
Exercises with equivalencies	21	4
Exercises with no equivalencies that could be completed in port or under way	79	22
Total	100	26

RECOMMENDATIONS

Based on the analyses described above, we developed several recommendations regarding the use of simulation for training in the surface force. In presenting these recommendations, our aim is to provide information that can help to

- make optimal use of underway training time
- guide decisions about whether to increase the use of virtual and live simulation in surface force training
- identify mission areas and kinds of exercises that would be appropriate targets for increasing the use of simulation, especially virtual simulation
- develop strategies for purchasing and implementing simulators.

Define the Goals of the Training

To determine the roles of live and simulated training in relation to performance goals, it is essential to establish the goal of training. If the goal is to achieve the greatest proficiency, more resources have to be expended or significant process changes need to be made. If the goal is to reduce cost while maintaining the same proficiency, the trade-offs may be different. Defining clear training goals could help to increase openness to the use of simulation for training.

Specify Measures of Effectiveness for Training

The Navy needs clear proficiency and readiness standards covering all phases of training across mission areas to assess not only the general effectiveness of training but also the efficacy of training through simulation. Given the experience of other organizations, it seems likely that live in-port or virtual simulation would be at least as effective as underway training for many skills. Evidence derived from well-defined measures substantiating such an outcome could be instrumental in producing change.

Increase the Efficiency of Underway Training

Underway training time should be reserved for exercises that can only be completed under way. The number of exercises with approved equivalencies should be expanded, and a much-higher

proportion of exercises with equivalencies should be completed in port. In addition, "underway only" exercises should be prioritized, with high-priority exercises being completed first. Finally, exercises should be sorted into groups that can be completed simultaneously, so as to maximize the training benefit from time at sea.

Develop a Simulation Strategy

To expand the use of simulation in a way that optimizes both proficiency and the use of training resources, we propose a three-pronged strategy. First, the Navy needs to clarify responsibility and authority for decisionmaking with regard to the use of simulation in training. Second, earning credit through training on shore-based simulators must be made permissible under the SURFTRAMAN. Third, the Navy should select areas for simulation in which simulation will provide the greatest benefit. In the following paragraphs, we identify several categories of such exercises.

Exercises for Which the Actions Taken Do Not Depend on the Location of the Ship. Exercises for which it is known that the actions taken or reactions to stimuli do not depend on the location of the ship should be regarded as candidates for simulation. For example, an antisubmarine warfare team can accomplish approximately the same level of training when the ship is tied to the pier, with external signals stimulating equipment, as it can under way.

High-Frequency Exercises. Logically, it seems that exercises that require repetition would be good candidates for simulation because the consistency of the training environment would allow users to develop and refine their skills without the intrusion of irrelevant factors that may undermine performance. It also seems likely that simulating high-frequency exercises would be more cost-effective than repeating exercises while under way, and the financial benefits of simulating high-frequency exercises could be maximized by focusing development efforts on the most-costly high-frequency exercises.

Exercises in Nontactical Mission Areas. Currently, all approved equivalencies are in tactical mission areas, but training for many nontactical missions could take place in port. The use of simulation by other militaries and the private sector indicates that engineering, ship-handling functions, and maintenance exercises are all likely candidates for simulation.

Exercises Simulated by Other Military Organizations and the Private Sector. As we have shown, other military organizations, commercial aviation, and commercial shipping use simulation for training to a much greater extent and with good results than does the U.S. Navy. The Navy is currently moving to align its qualification standards with those of the merchant marine. As this process goes forward, it should focus not only on standards but also on methods of meeting those standards. The use of simulation for training should be given a key role in defining these methods.

Develop an Investment Strategy

The Navy should invest in the simulators that afford the best fidelity and maximize their availability. Heretofore, limited availability of simulators with good fidelity has hindered the expansion of training through simulation.

Because there are multiple simulators for the same exercises, it appears that the direction of simulation has been to improve the fidelity of what has already been simulated. Although fidelity is, of course, important, fidelity may already be satisfactory in some areas, making it desirable to give greater attention to developing simulators for new mission areas.