



NAMRL Special Report 96-2

**LANDING CRAFT AIR CUSHION (LCAC)
VEHICLE CREW SELECTION: AN
OVERVIEW**

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**NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
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SELECTION: AN OVERVIEW**

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ABSTRACT

This report provides an overview of the research conducted at the Naval Aerospace Medical Research Laboratory (NAMRL) to improve Landing Craft Air Cushion (LCAC) crew selection. The report includes background information, crew task analysis procedures, identification of critical skills, and the development of selection tests. In addition, the report provides a description of the test battery, the prediction algorithm, and initial results of the selection system for certain crew members. Prior to the implementation of the selection system, the attrition rate for operators and engineers was unacceptably high, ranging from 35 to 41%. To date, the attrition rate for operators and engineers has declined dramatically to approximately 15% with the use of the LCAC Selection System (LCSS). The LCSS proved to be a cost-effective method of reducing the high costs associated with training attrition and equipment loss. Additionally, the report describes current activities and presents direction for future research. A list of publications related to the LCAC program is also included.

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INTRODUCTION

The purpose of this report is to provide an overview of the research and system development conducted at the Naval Aerospace Medical Research Laboratory (NAMRL) to examine the critical issues associated with Landing Craft Air Cushion (LCAC) crew selection. Before 1988, no research-based LCAC crew selection system was in existence. Operators were selected based on their rate, their interest in the LCAC program, and a commanding officer's recommendation. However, attrition rates were unacceptably high, ranging from 35 to 41% (Eakin, 1990). As training costs escalated and projected plans called for more LCAC vehicles and crews, selecting candidates who would be successful in the operation of complex machinery became more critical. The NAMRL was tasked with reducing training failure rates by developing a selection system to identify those individuals who would most likely complete operator or engineer training. The primary objective of the project was to develop tests involving cognition, psychomotor, multiple task, and biographical and personality inventories having the potential to predict Phase I training outcomes of the LCAC crew.

Background Information

The LCAC vehicle is an amphibious warfare vessel, designed to transport weapons, armored vehicles, equipment cargo, and personnel of a Marine Air/Ground Task Force both from the ship to shore and across the beach. This vehicle is capable of operating from well-decked ships and can deliver a 60-ton payload at speeds exceeding 40 knots. The vehicle is propelled by four gas turbines connected to four centrifugal lift fans and two thrust fans. Due to its bag and skirt lift system, the LCAC vehicle is operable in both land and sea environments and can clear 4-ft. obstacles. The LCAC's ability to maneuver at high speeds reduces the risk of exposure to larger assault transports while improving the reach of amphibious operations.

Similar to a helicopter in that it has three dimensions of motion, operating the LCAC requires unique perceptual and psychomotor skills to operate. Control of the LCAC is similar to an aircraft although vehicle responses to control inputs are much slower and less precise in comparison. The LCAC's high speed capability and maneuverability are unlike any other surface combatant vessel in the United States Navy. The LCAC's ability to traverse over land and water exposes 70% of the world's beaches to amphibious assault, compared to 17% with conventional landing crafts. In a typical mission, the LCAC will embark equipment, troops, and/or supplies, launch from amphibious ships, transit at high speeds to the beach under assault, transit the surfzone and beach, proceed inland to a suitable offload site, offload rapidly, and return to the amphibious ships for reload and follow-on sorties.

Beyond these capabilities, Smith, Shaw, Zito, and Jandreau (1995) examined the potential of the LCAC to provide casualty care in amphibious operations on board the USS WASP (LHD-1). The LCAC is being assessed in terms of its potential operational capabilities for retrograde transport of casualties using the Marine Corps Expeditionary Shelter Station (MCESS) and the

Personnel Transport Module (PTM). (For a description of the units, see *Navy Medicine*, January-February 1995). The equipment would allow the LCAC to serve as a beachfront surgical stabilization platform. An LCAC medical or surgical treatment team could provide for initial on-site care and treatment as well as preliminary sorting of assault casualties. The medical team could stabilize patients while the LCAC transports the casualties to ships located over the horizon (OTH). As a result, this activity would free up the aviation assets typically used for patient transport. In addition to its medical capabilities, the LCAC is being assessed for its potential as a mine-sweeping unit. The LCAC may also require additional trained personnel, specifically in weapon systems operation.

The LCAC Crew

The LCAC crew consists of five enlisted positions: craftmaster, engineer, navigator, loadmaster, and deck mechanic. Briefly, the craftmaster or operator is responsible for craft operation and leadership of the crew. The engineer is considered the assistant craftmaster and is responsible for maintaining equipment logs and inventories as well as the maintenance and monitoring of onboard equipment. The navigator is responsible for maintaining and monitoring navigation equipment as well as plotting courses. The navigator is also responsible for LCAC personnel and training logs maintained ashore. The loadmaster is responsible for organizing load plans and for securing and monitoring all deck cargo. The loadmaster also serves as the port side lookout. The deck mechanic works with the engineer on the maintenance and monitoring of onboard equipment. The deck mechanic and the loadmaster are responsible for line handling during mooring and anchoring. The defined responsibilities of the individual LCAC crew members enable them to work as a cohesive unit in order to identify the landing site and transit the LCAC effectively.

CREW SELECTION RESEARCH

Identification of the Critical Tasks

The initial step in the development of an LCAC operator selection system was to interview key personnel in the LCAC community to identify the skills and abilities necessary to be a successful crew member. We conducted interviews at various training sites including Panama City, Florida, Assault Craft Unit (ACU)-4, Little Creek, Virginia, and ACU-5, Camp Pendleton, California. The information collected provided performance criteria to be utilized in LCAC crew candidate selection. The results of the interviews also indicated that the LCAC crew personnel have a greater responsibility for maintenance of the craft in comparison with aviation crew personnel. When combined, these factors place both physical and mental demands on crew members as well as create the need for teamwork and cooperation.

DEVELOPMENT OF THE SELECTION SYSTEM

Landing Craft Air Cushion Crew Selection System (LCSS)

The results of the interviews showed that operation of the LCAC requires multi-limb coordination, integration of perceptual information, rapid cognitive processing abilities, fine psychomotor skills, and time-sharing ability. Thus, skills required to operate the LCAC vehicle resemble those necessary to fly an aircraft. The NAMRL aviation selection research test battery was modified for use in the validation phase of the project (Dolgin & Nontasak, 1990; Nontasak, Dolgin & Blower, 1991).

The validation of the test was carried out using 42 LCAC crew members. The test battery assessed psychomotor abilities (eye-hand-foot coordination), divided attention, reaction time, intelligence, personality and interests, and biographical information. Several classification variables were recorded for each subject: included age, number of hours in the LCAC program, military rating/classification, and geographical location of billet (east versus west coast). The subjects ranged in age from 24 to 44 years ($M = 32.5$, $S.D. = 5.34$) and had successfully completed a minimum of a high school education. The mean number of hours they had operated the LCAC was 349.25. The experimental test battery took approximately 2 ½ h. to administer.

Subjects' performance on the test battery was compared with their performance in Phase I LCAC training. The results indicated that the psychomotor, divided attention, and reaction time tests had the strongest relationship with training performance (Nontasak, Dolgin & Griffin, 1989; Nontasak & Dolgin, 1990). Since other ability tests, such as intelligence measures, demonstrated no significant relation to performance in training, they were eliminated. This is not to suggest that intelligence is not a factor for predicting training performance; but rather that previous selection measures, such as the Armed Services Vocational Aptitude Battery (ASVAB), are already selecting candidates on characteristics such as intelligence.

Once the valid tests were identified, a selection model was developed. Although this model was still in the experimental phase, better qualified candidates were needed urgently. As a result, LCAC crew candidates were selected based on this model on a prototype implementation basis. All candidates for the program were required to report to NAMRL and, based on their test performance, a recommendation was made to Naval Bureau of Personnel (BUPERS) regarding whether or not a candidate should enter Phase I training. Between 1988 and 1990, a series of new experimental tests were continuously assessed. However, candidates were recommended solely on their performance on tests found to be predictive of Phase I training performance.

In early 1990, the final test battery, referred to as the LCAC Crew Selection System (LCSS), was put into operational use. The LCSS has been continuously modified as new criterion data become available. The test has remained the same, yet the weights attached to the individual subtests were changed as a result of additional criterion data used in the discriminant analysis.

Initially, the selection system was implemented to select operator candidates, however, the engineer candidates continued to be tested for research purposes.

To date, both the engineers and operators are selected using a multiple hurdle approach. The hurdles consist of obtaining a minimum score of 204 on the ASVAB subtest, passing a rigorous physical examination, and passing the LCSS. A recommendation for training is made based on their performance on the LCSS, but the final decision is ultimately made by BUPERS. In October of 1992, the LCSS was transitioned to the Naval Aerospace and Operational Medical Institute (NAMI) for selection of both operators and engineers.

Development of the Prediction Algorithm

The LCAC selection system contains an algorithm for predicting the success or failure of an individual candidate who might possibly undergo training for the position of operator or engineer. The actual implementation of the algorithm in the software code is quite simple. Five variables from the psychomotor test battery are weighted and then combined to form a composite score. This composite score is assumed to be a good indicator for the more complex psychomotor skills relevant to success during LCAC training. Each candidate's composite score on the test battery is then compared to a threshold score. If a candidate's composite score is greater than or equal to the threshold score, the candidate is predicted to pass training, while a composite score below the threshold results in a prediction of failure for the candidate.

The variables and associated weights that make up the composite score are derived through the statistical technique of discriminant analysis. Briefly, the scores were constructed such that the distance between the mean score of those who eventually passed training and the mean score of those who eventually failed training was as far apart as possible. At the same time, the variance of the composite scores was kept to a minimum for each of these two groups. The algorithm has been updated as additional criterion data become available. For a complete description of the algorithm, see Appendix H in the LCAC Crew Selection System Upgrade I User's Manual (Chapman & Nontasak, 1995).

The Test Battery

The LCSS is a menu-driven computerized test that consists of two performance-based tests and a biographical and personality inventory. In terms of basic computer hardware, the battery requires an IBM or PC-compatible computer (386/25MHz or greater), VGA monitor, two joy sticks, rudder pedals, keyboard, numeric keyboard, headphones, game card, and sound card (see Appendix A).

The first performance-based test is referred to as the Psychomotor and Dichotic Listening Test (PMT/DLT). This test is a measure of eye-hand-foot coordination and divided attention. The subject's task is to maintain cursors on appropriate targets while performing a listening task. The PMT/DLT is made up of seven different subtests each increasing in complexity. The subject starts with a single task, controlling a cursor with the center joystick. Next, the DLT is

introduced. In the DLT test, the subject is presented with a different stream of numbers and letters into each ear simultaneously. The subject's task is to key in only the numbers heard in the ear as specified by the computer.

The third subtest requires the subject to perform the first two tasks simultaneously. Next, subjects are required to control a second cursor with the rudder pedals in addition to controlling the center cursor. In the fifth sequence, the DLT is added. The sixth subtest requires the subject to control three cursors, the two previously mentioned and another controlled by a joystick to the subject's left, also called throttle. The final subtest requires the subject to control all three cursors and respond verbally to the DLT. The scores on the PMT portion of the test are essentially tracking errors. These are calculated by the computer and given as the sum pixel errors away from the target averaged over multiple trials. Tracking error is computed for each PMT subtest. Performance on the DLT is evaluated by the number of correct responses.

The second performance test, the Horizontal Tracking (HT) and Digit Cancellation (DC) test is a measure of two-dimensional tracking ability, time-sharing skill, and reaction time. This test is composed of three subtests. The first subtest requires the subject to keep a square centered in a rectangle. The subject controls the square with the center joystick. A forcing function causes the square to move away from the center. Therefore, the subject must make constant adjustments to try to maintain the cursor in place. In the second subtest of the HT/DC test, the subject is presented with numbers on the screen one at a time. The subject's task is simply to press the key corresponding to the number on the screen. Finally, the subject is required to perform both tasks simultaneously. The horizontal tracking task scores are determined by the sum pixel errors away from the center of the rectangle averaged over multiple trials. The digital cancellation scores include mean reaction time and accuracy for each trial.

The biographical inventory requires the candidates to answer some background questions and rate themselves on different perceived abilities. The personality inventory (social desirability scale) is designed to determine if candidates are trying to present themselves in a positive or negative manner (please refer to following section on personality measures). We did not find this test useful in predicting the performance of operators and engineers, so we dropped it from the test battery. For a comprehensive description of the test battery, refer to the LCAC Selection System Manual (Helton, Nontasak, & Dolgin, 1992).

RESULTS OF THE LCAC SELECTION SYSTEM

As of November 1995, we have tested 180 LCAC crew candidates using the LCSS (see Table 1). Of those tested, 150 (83%) candidates were recommended for Phase I training. To date, 67 of 79 (85%) candidates have successfully completed Phase I training. Forty-three of 45 (96%) candidates have successfully completed Phase II training. The remaining 71 recommended candidates tested are expected to begin training during FY96. Prior to the implementation of the selection system the attrition rate for operators and engineers was unacceptably high, ranging from 35 to 41%. To date, the attrition rate for operators and engineers has dramatically reduced

to approximately 15% with the use of the LCSS. The LCSS proved to be a cost-effective method of reducing the high costs associated with training attrition and equipment loss.

Table 1.

LCAC SELECTION SYSTEM EFFECTIVENESS

Total Candidates Tested (N =180)

	Phase I (N = 79)	Phase II (N = 45)
Pass	67 (85%)	43 (96%)
Fail	12 (15%)	2 (4%)

Personality Measures

Concurrent with the development phase of the LCSS, research was conducted at the NAMRL to examine the influence of personality as a predictor of training performance. Beginning in November 1989, data on personality measures were collected using the Adult Personality Inventory (API) and analyzed based on the five-factor model (extroversion, neuroticism/emotional maturity, openness/practicality, agreeableness, and conscientiousness). Research was conducted during the validation phase of the LCSS using the LCAC operator candidates (Street & Helton, 1993; Street, Helton, & Nontasak, 1993). The primary finding indicated that one personality variable, openness/practicality, significantly improved predictions of the criterion. Personality measures are not used for final selection decisions for LCAC training.

Supporting/Additional Research

In 1993, The Naval Health Research Center (NHRC) examined the medical and operational issues associated with LCAC operations in order to determine permanent crew medical standards (Hunt, Linnville, Stuster, Schneider, & Braun, 1993). Researchers from NHRC observed a series of both day and night training missions conducted at ACU-4 and ACU-5 involving multiple well-deck approaches and landings. They also observed vessel inspections, start-up procedures, ramp transits, off-shore operations, beach approaches and landings, and shut-down and clean-up procedures. The researchers attended pre-mission briefings and reviewed training and maintenance documents for information concerning task performance.

The operational task lists for each individual LCAC crew member ranged from 113 (deck mechanic) to 195 (engineer). The information compiled allowed researchers to develop task-specific questionnaires and ability ranking forms. A final review of the task list was conducted by expert crew personnel. Both instructors and students were surveyed to determine the specific tasks in terms of the task's overall criticality, its difficulty to learn, and its importance for mission success. General results indicated that the LCAC crew must operate effectively in "moderately to highly stressful environments operating complex and expensive equipment, and are called upon frequently to make prompt and consistently accurate decisions."

CURRENT LCAC SELECTION RESEARCH

Development of the LCAC Navigator Selection System

The Naval Sea Systems Command (NAVSEA) has requested that the NAMRL develop and validate an LCAC navigator selection system to complement the LCSS. The request was prompted partly by the fact that the LCAC navigator trainee failure rate during 1993-1994 was 44%. Assessment of the skills and abilities associated with the unique task demands of the LCAC navigator is necessary to identify the selection criteria. Researchers at NAMRL followed a similar protocol used in the design of the engineer and operator selection systems. Navigator instructors and students at ACU-4 and ACU-5 were provided with the comprehensive list of operational tasks for the navigator position. The individual tasks were ranked on a seven-point Likert scale in terms of their difficulty to learn and their overall criticality to successful operation.

Based on the task ranking, several tests were identified that assess the critical performance areas. The initial navigator selection system will encompass several of the LCSS psychomotor subtests as well as the computerized version of the Complex Visual Task (CVT). The CVT is a test designed to assess an individual's ability to encode verbal information and manipulate pictorial displays in short-term or working memory. The CVT relates to training performance among the Navy's flight officers (Morrison, 1988). The CVT was selected for use in an experimental selection battery for the position of LCAC navigator due the similar nature of the job demands. Additional tests to be used include the Manikin test, which assesses mental rotation and visuo-spatial ability, as well as a time-distance estimation task. Subject testing is ongoing at both training sites and will continue into FY96. Upon validation, the final test battery will become a part of the larger LCSS.

LCSS Foreign Purchase

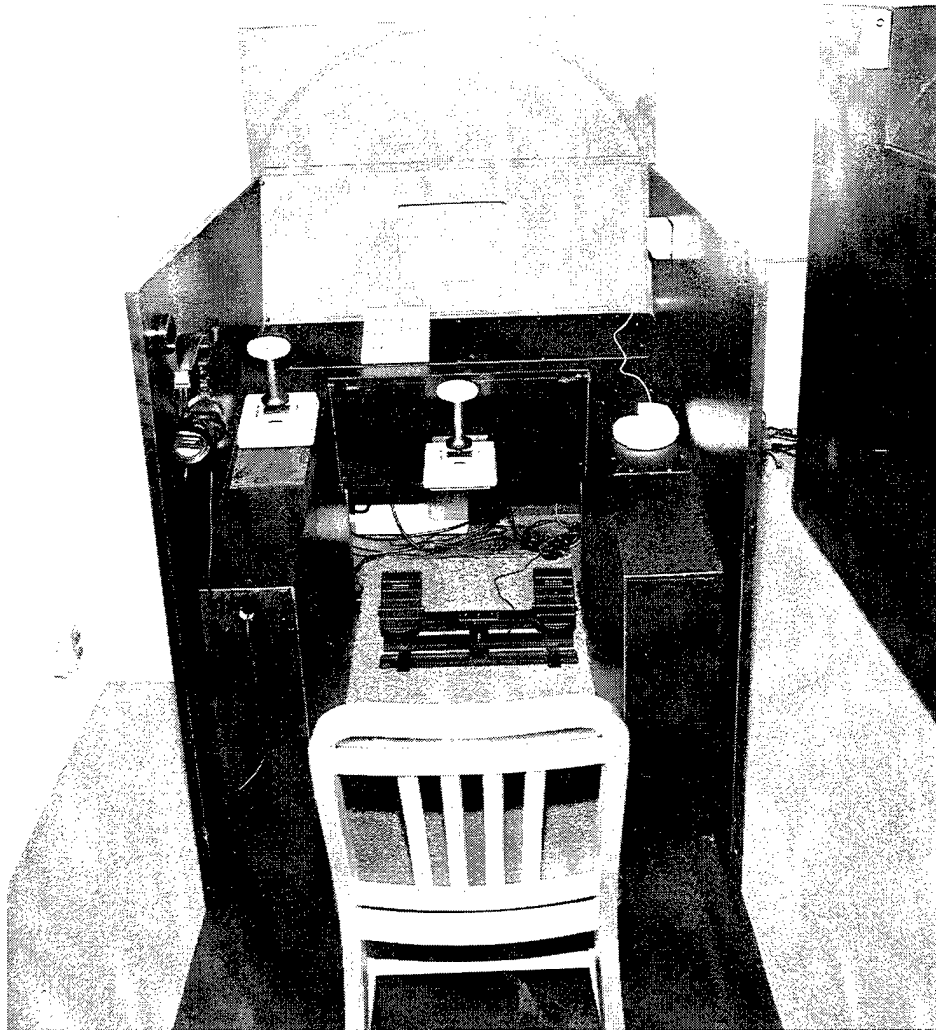
The Japanese Defense Force purchased five LCAC vehicles from the United States Navy. Training for LCAC crew positions will be performed by the United States. Due to high costs associated with training and the effects of training failures on operational readiness, the Japanese Defense Force requested the use of the LCSS. The LCSS software and its manual were delivered to the Japanese in the winter of 1994. The NAMRL will have access to the test data collected for use in comparative analyses.

DIRECTIONS FOR FUTURE RESEARCH

A viable direction for future research is the development and implementation of selection systems for the two remaining crew positions to reduce their associated attrition rates. As a result of recent policy changes, future research also needs to address issues related to female candidates entering LCAC training and LCSS validation. In addition, as potential LCAC weapon system capabilities expand to incorporate medical support and mine-sweeping faculties, selection research needs to address the personnel skills and abilities necessary. Lastly, future research needs to determine the efficacy of the LCSS to predict performance in the LCAC simulator (Full Mission Trainer). As LCAC personnel continue to expand and diversify, research and development in the selection arena needs to determine the critical skills and abilities necessary for continued success.

Appendix A

LCSS SYSTEM SETUP



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