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September 1987

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Final Task Report

**SIMULATION AND EXPERIMENTS TO DETERMINE
COMMUNICATIONS IMPACT ON PERFORMANCE
MEASURES IN LOGISTICS**

**TASK 3--PORTABLE AIRCRAFT FUEL TANK
ASSEMBLY SYSTEM
FEASIBILITY EXPERIMENTS FOR SIMULATION
AND MODEL VERIFICATION**

Contract No. N66001-84-D-077, D.O. 0025
Report Period: 23 September 1986 to 4 April 1987

By: GERRY B. ANDEEN CARL E. BLAHNIK RICHARD H. MONAHAN

Prepared for:

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

and

DAVID W. TAYLOR NAVAL SHIP
RESEARCH AND DEVELOPMENT CENTER
BETHESDA, MARYLAND 20084

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PREFACE

This report documents the results of research conducted for the Naval Ocean Systems Command (NOSC), San Diego, California, and the David W. Taylor Naval Ship Research and Development Center (DTNSRDC), Bethesda, Maryland. The technical monitor for NOSC is G. L. Allgaier, Code 444. The research is in response to DTNSRDC under the direction of M. J. Zubkoff, Code 1870. The research was performed under Contract N66001-84-D-077, D.O. 0025.

The SRI program manager for the overall contract was F. F. Kuo of the Computer and Information Sciences Division (CISD). D. L. Nielson is Vice President of CISD. R. H. Monahan of the Systems Development Division (SDD) was the project manager for this delivery order. J. P. McHenry is Vice President of SDD.

The research on Task 3, the subject of this report, was performed in the Advanced Technology Division (ATD). W. F. Greenman is Vice President of ATD. G. B. Andeen was the task leader, and C. E. Blahnik was the lead design engineer. Both are members of the Mechanical Research Laboratory of ATD.



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I INTRODUCTION

A. Objective

The objective of this delivery order was to establish an estimate of the impact of communications on (1) performance measures relating to the logistical aspects of theater-level war games and fleet exercises, and on (2) the physical distribution of critical components to support C₂ operations during sustained periods of naval combat operations. The research was conducted in accordance with the following three task statements:

Task 1: Communications Impact on Performance Measures in Logistics

The contractor shall define a set of logistics performance measures to model the effectiveness of logistics systems and procedures within the context of joint theater-level war games and fleet exercises. The relationship between these performance measures and communications effectiveness shall be established.

Task 2: Communication Performance/External Aircraft Fuel Tank Availability Tradeoffs

The contractor shall perform the required modifications to the physical distribution system computer simulation model FTANKS to provide for the assembly, recovery, and reuse of disposable external aircraft fuel tanks during combat operations.

Task 3: Portable Aircraft Fuel Tank Assembly System Feasibility Experiments for Simulation and Model Validation

The contractor shall provide a design of a portable fuel tank automated assembly system for demonstrating the feasibility of using such an assembly system within an aircraft carrier battle group for assembly of nestable, disposable external aircraft fuel tanks during combat. (JF)

operations. The developmental fuel tank assembly system will be housed within a 20x8x8-ft portable container that is transportable between the aircraft carrier and one of its support ships.

The results of the research performed under Task 3 are presented in this report.

B. Background

The science of logistics is a technical integration of many supportive disciplines such as acquisition and supply, replenishment, reliability and maintainability, and advanced basing. The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) logistics technology program involves the analysis of support requirements associated with air vehicle technology and the logistics effects of Fleet operational performance. To that end, air logistics technology support is required in the conduct of Fleet performance simulation exercises to determine logistics requirements of air vehicles.

A need for exploratory development research has arisen concerning the adequacy of aircraft fuel tanks in the fleet, tank storage locations, methods for tank distribution, system responsiveness to need, and alternatives for acquiring such tanks. Failure to have adequate responsive access to such fuel tanks will have a deleterious effect on operational readiness of Fleet aircraft and, consequently, on carrier battle group readiness.

Previous research has indicated that the development of disposable, nestable aircraft external fuel tanks with automatic assembly aboard ship is feasible.* A preliminary cost-benefit analysis of several design concepts for nestable fuel tanks indicated that the effectiveness of task group air combat operations can be significantly increased with

* Andeen, G. et al., "Physical Distribution System for Aircraft External Fuel Tanks - Candidate System Design Evaluations," SRI Project 1076, DTNSRDC Report No. CMLD-CR-58-86 (November 1986).

the availability of nestable fuel tanks. For one of the candidate design concepts (a three-piece welded aluminum tank), conceptual designs for both an automated and semiautomated portable fuel tank assembly system were drawn up. These designs could be used to demonstrate the feasibility of the use of the assembly system aboard ship. The next step toward conducting a demonstration is to generate a detailed design for one of these conceptual assembly systems. Development of this detailed design, as indicated by the statement for Task 3 in the previous subsection, was the objective of the research described in this report. A semiautomated assembly system was selected by DTNSRDC for use in subsequent demonstrations.

II CONCEPTUAL DESIGN

The original conceptual design for the semiautomated portable fuel tank assembly demonstration facility is illustrated in Figures 1 through 3. The assembly station is housed in a standard shipping container (20x8x8 ft). Within the container are a weld station and a test station. The parts are loaded into the weld station, where they are welded and then transferred to the test station. After testing, the tanks are removed, ready for use. Figure 1 illustrates an internal assembly station layout plan; this station assumes joint operation of both the weld station and the test station.

The weld station is an adaptation of a conventional weld lathe with head and tail stocks and two welding heads. The three tank parts are loaded through an open end of the container into the weld station. The operators remove the nose piece from the pallet, place it on the weld-lathe lateral transport rollers, and move the nose to the front position. They then remove the midsection from the pallet, place it on the weld-lathe lateral transport rollers, and move the midsection to a position to mate with the nose piece. Next, the operators remove the tail piece from the pallet, place it on the weld-lathe lateral transport rollers, and move it to a position to mate with the center section. The operators then mate both the end sections with the center section and turn on the dual weld lathes. The welding is automatic with each weld head tracking the seam to be welded.

Upon completion of the welding of one tank, the previously welded tank should be completing its test cycle. The operators detach the air line and roll (or lift) the tested tank off the end of the test facility. The tank at the weld station is then transferred, with operator assistance, to the test station (Figure 2) where it will be subjected to pressure testing. An operator lowers the test fixture (air hose in the illustration) to its side position, attaches the pressure line, and begins the

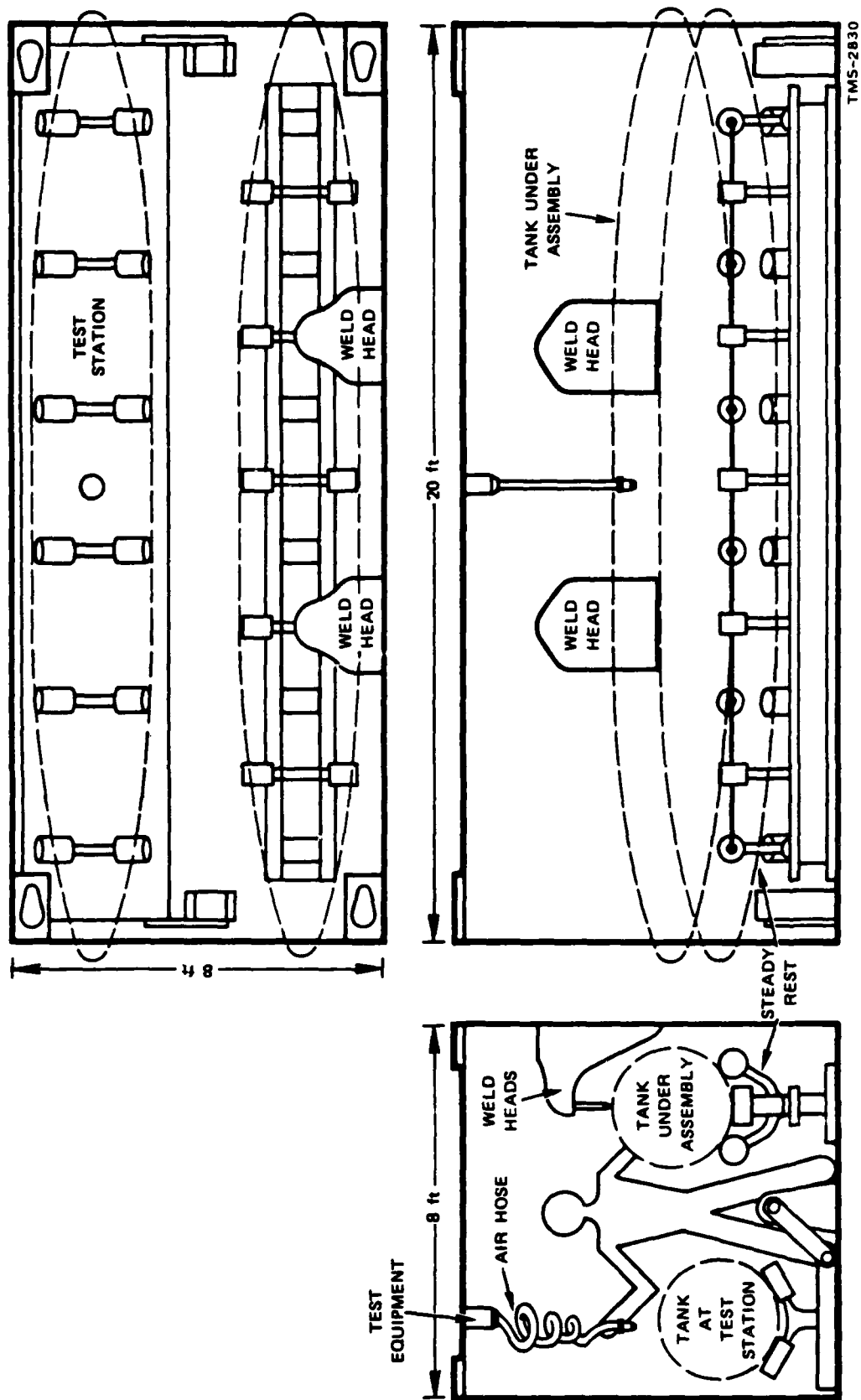
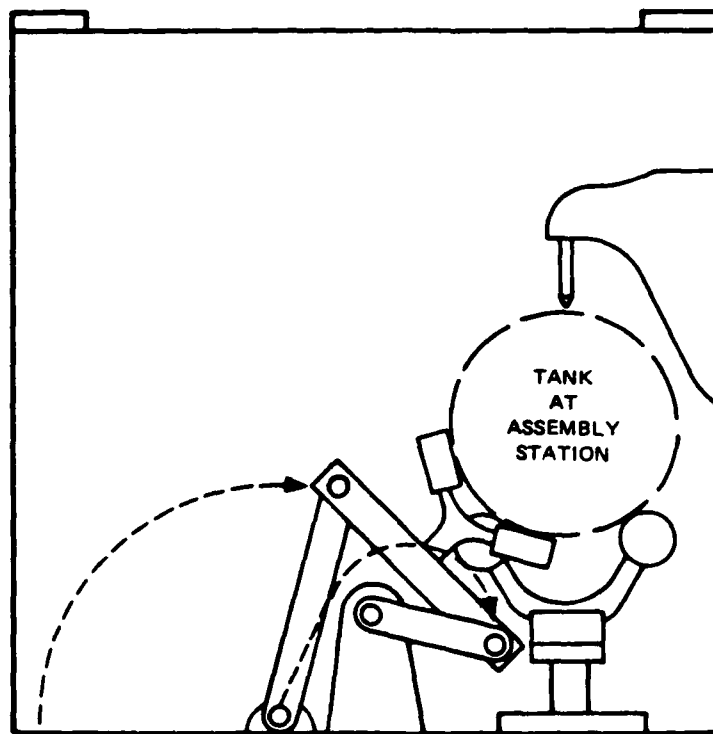
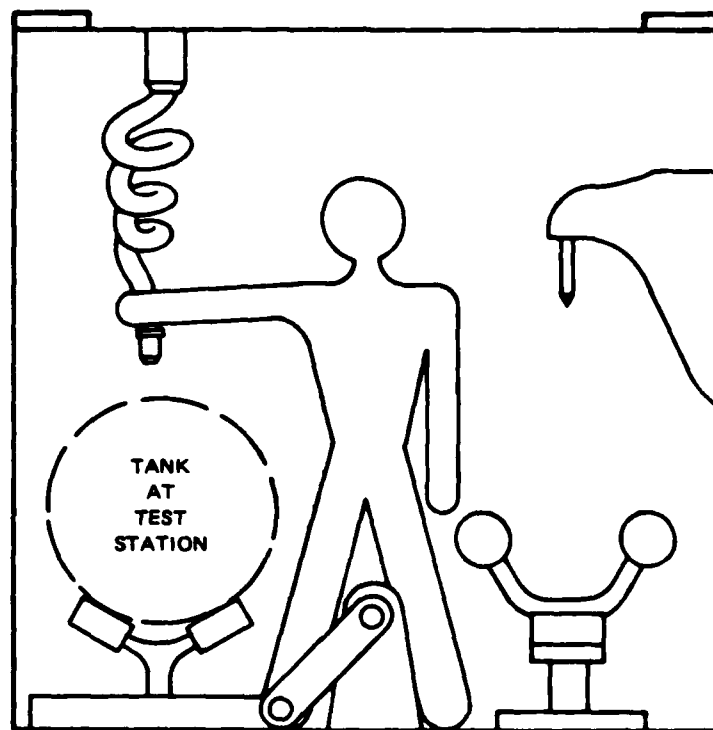


FIGURE 1 CONTAINER ASSEMBLY DEMONSTRATION FACILITY



(a) TEST BED ROTATED TO ACCEPT WELDED TANK

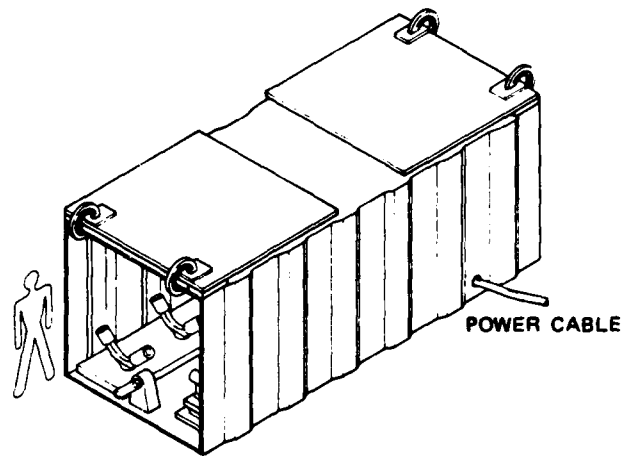


(b) TEST BED WITH WELDED TANK ROTATED BACK TO TEST STATION

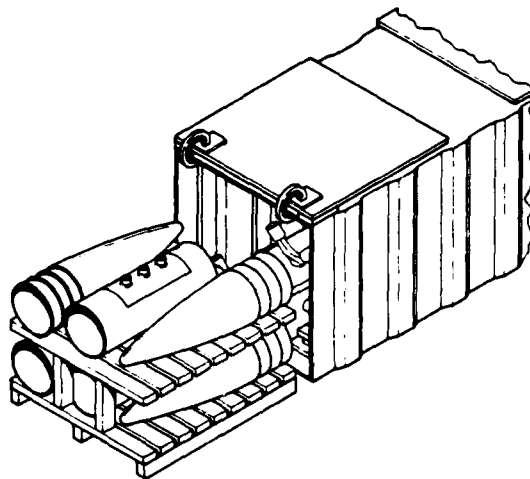
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FIGURE 2 TRANSFER CONCEPT

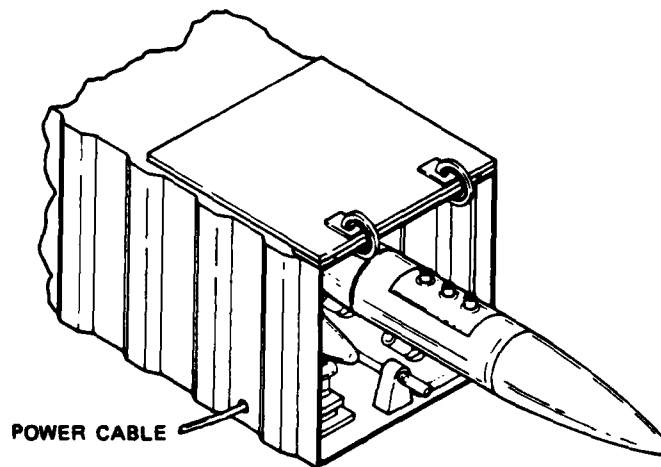
automatic testing cycle. The operators then begin loading in the next tank parts to be welded. Figure 3 illustrates the sequence of operations from an external view, showing the container itself and the pallets on which the tank parts are stored and eventually delivered to the assembly station.



(a) READY FOR ASSEMBLY



(b) RECEIVING PARTS



(c) DELIVERING ASSEMBLED AND TESTED TANK

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FIGURE 3 CONTAINERIZED ASSEMBLY STATION

III DETAILED DESIGN

A. Design Criteria

The demonstration facility is not intended to be like the final assembly station but to demonstrate the capabilities needed and to address critical issues. The conceptual design described in the previous section served as the basis for the detailed design of the assembly station and also as the basis for the associated demonstration fuel tanks.

Aircraft external fuel tanks are currently assembled in a manner similar to that described in the previous section. Key differences in the conceptual design involve the methods of welding and testing, both of which trade off quality for speed and economy. These trade-offs are essential if fuel tank production is to meet projected rates.

Current fuel tank production uses the tungsten inert gas (TIG) welding process, which produces a high quality, pore-free, and smooth weld that is flush with the skin surface. However, the metal inert gas (MIG) welding process is at least four times faster than the TIG process. Although the appearance and quality of the MIG welds will not be as good as those of the TIG welds, they are expected to be more than adequate, functionally.

The testing methods in current fuel tank production can be highly reliable but time consuming. For example, hydrostatic testing and X-ray examination can both be used to determine if fuel tanks meet design requirements. However, these testing processes both require a large amount of time. For the demonstration assembly station, the tanks will be tested for leaks under low pressure. Gases can be injected quickly into the tanks, and the gases can be easily and inexpensively detected by using techniques common for testing leaks in refrigeration equipment. This type of testing should provide sufficient confidence in the quality of the welded fuel tanks. More severe tests could then be performed off-line later to verify the integrity of the welds.

A preliminary design of a demonstration assembly station and its associated test tank was drawn up and discussed at a meeting between SRI and DTNSRDC personnel. During this meeting, a number of critical issues were identified and agreement was reached about how best to address them. The results of this meeting can be summarized as follows:

- A tank shorter than the intended operational tank will be used for demonstrations. The tank will have a cylindrical center section, and, generally, conical nose and tail sections with spherical end caps.
- The weld station will perform two welds at the same time.
- Operators will be allowed to continuously adjust the axial position of the welding equipment during a demonstration, although automatic seam tracking is preferred.
- A leak test station will be provided in the test container. Tanks will be hydrostatically tested elsewhere to demonstrate that the leak test is sufficient to indicate weld integrity.
- Parts will be hand-loaded to the weld station, the welded tank will be transferred to the test station by transfer racks, and the tanks will be unloaded with manual assistance.
- Consideration will also be given to recognizing and responding to shipboard concerns such as fire safety. Cut-outs, extinguishers, and other appropriate gear will be installed or mocked-up to illustrate that the concern has been recognized.

B. Assembly System and Tank Design

The assembly station has been designed as an independent unit to fit into a standard 20x8x8-ft shipping container. The intent is to do some testing before anchoring the equipment inside the container. The design involved specifying a welding lathe and associated equipment, designing the transport and transfer mechanisms, establishing the test method, identifying the amenities such as lighting and ventilation, and making sure that all components will fit and function properly. The facility has been designed to operate on ordinary power (110V-60 cycle ac for lighting, fans, winches, and the like, and 220V-60 cycle three-phase power for the welding equipment) and shop air for tank pressurization and pneumatic actuators.

In addition to a three-piece test tank, a learning tank was designed. The learning tank has removable flanges that can attach to each end of the large center and end sections. Each time a test weld is made, the tank can be handled in the usual manner. However, the removable flanges are welded together, not the tank sections themselves. After each test, the welded flanges are removed. With this procedure, the tank center and end sections can be used over and over again with new sets of flanges. Use of the learning tank can facilitate welding practice and establish proper equipment settings.

Drawings and specifications have been provided to DTNSRDC personnel. In addition, these drawings and specifications were sent to three companies that provide welding equipment appropriate for the demonstration test station. A qualified bid within our budgetary estimate was received from Jetline Engineering, Inc., of Irvine, California. Their expected delivery time is eight to ten weeks from date of order.

Container Marketing, Inc., of Oakland, California, was identified as a supplier of a shipping container that would be modified for our use. Various other vendors have been identified for components (rollers, bearings, fans, etc.) and for producing spinning molds and components. Suppliers of materials with critical delivery times have also been identified.

A location at the SRI facility has been set aside for assembling the equipment into the container and for performing subsequent demonstrations.

In summary, the preliminary detailed design effort to demonstrate a semiautomatic assembly station for aircraft external fuel tanks has been completed. The preliminary design of the assembly station and test tanks has been made to illustrate critical features that have been deemed necessary to demonstrate. Vendors for important components have been identified, and bids within estimates have been obtained.