

# Helicopter Fault Isolation Equipment Evaluated by Army, Navy, Air Force

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A portable 20-pound device called LOGMOD (Logic Model) can locate malfunctions in helicopter systems, such as gun turrets, flight control systems and electrical-hydraulic subsystems, isolate the fault, then tell you how to correct it.

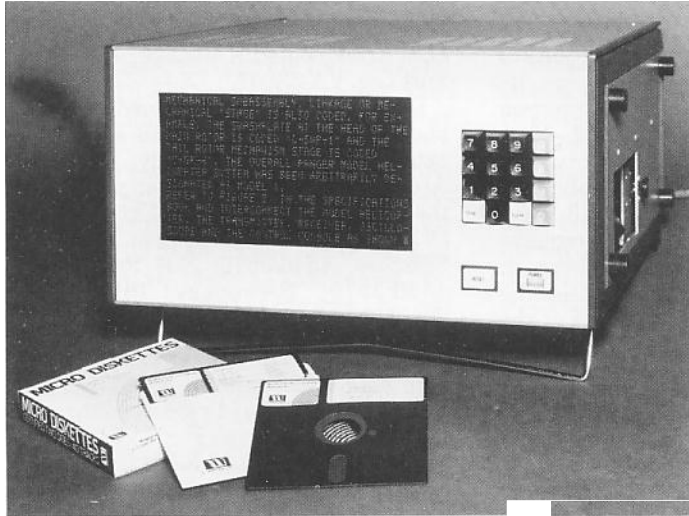


Fig. 1. LOGMOD fault isolation equipment includes TV-type screen and push-button control panel. In foreground are floppy discs, similar in appearance to 45 rpm records, which can carry several million bits of information.

The Air Force is using LOGMOD to check out AN/APN-147 doppler radar systems on C-141 aircraft, the Navy is using it to check out complex special under-water surveillance gear called BRD-7, and the U.S. Army Missile R&D Command (MIRADCOM) plans to apply LOGMOD to production-line electronics inspections.

Described as "putting the brains of the designer and

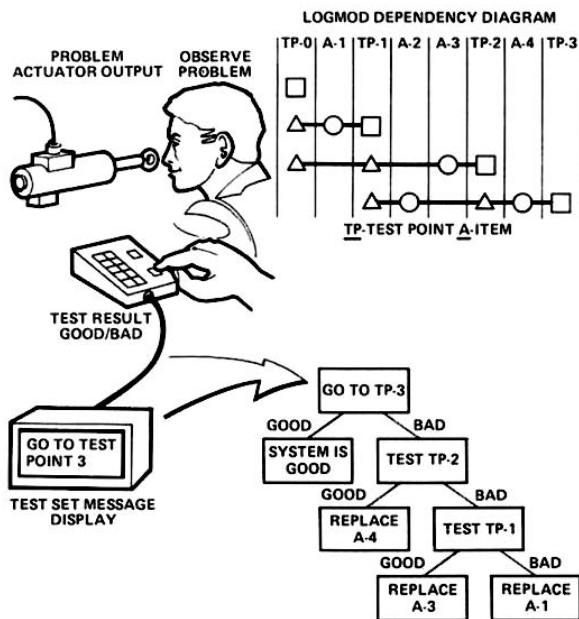


Fig. 2. LOGMOD Flow of Information

maintenance expert into a box for use by others to perform quick, accurate equipment inspections," this versatile unit can be operated by a technician after 30 minutes of instruction. In addition to the printed directions that appear on the screen, LOGMOD will provide hard copies on re-request (see Fig. 1).

For the past several years, the Advanced Systems Research Office of the U.S. Army Research and Technology Laboratories (RTL), AVRADCOM, has been developing a concept for diagnosing and fault-isolating helicopter systems. This concept is considered an engineering innovation in that no prior mathematical basis existed. A theoretical basis was developed by RTL which resulted in identification of several properties applicable to a variety of systems for performing design and maintenance analyses.

The logical basis of this idea is founded on the fundamental relationship that exists between the components of a system (hardware). In implementation, it is simple to transform design information, such as that found on engineering drawings, to a set of logic data characterizing the intrinsic functional dependence within a system.

Using this data as input, a Logic Model (LOGMOD) of the hardware can be generated. This forms a road map of logical flow of functional information (see Fig. 2).

LOGMOD originally was seen as an evaluation tool to be used at the design stage to assess maintenance parameters and fault-isolation characteristics of hardware, such as the minimum number of test points required for conclusive detection of system malfunctioning, frequency of usage of each test point in diagnosing all potential system malfunctions, and the best ways to track down a malfunction. Later, it was realized that this same tool could be used by maintenance personnel for inspection and fault-isolation.

For these reasons, a logic model device was built to demonstrate how a technician can use the technology to fault-isolate complex or sophisticated systems without requiring any knowledge beyond how to perform the test measurements. Fig. 3 presents the elements of the LOGMOD technique.

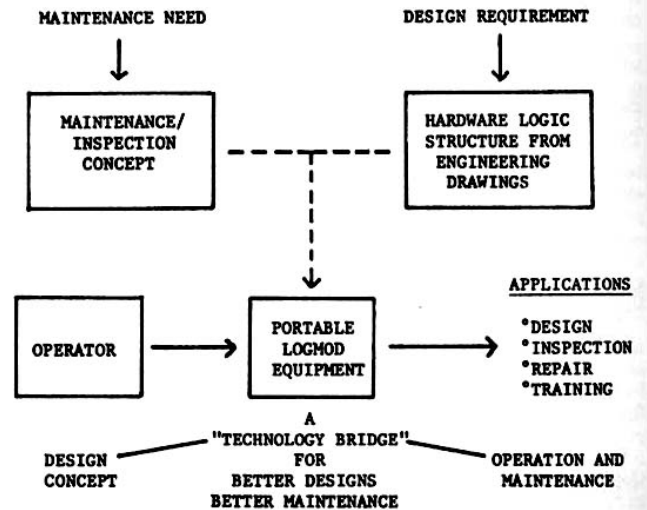


Fig. 3. Elements of LOGMOD Technique

LOGMOD does not simply contain a fault tree; it operates on the actual functional dependency logic of the hardware design of a unit being tested to show where and what test is needed. A large TV type screen shows testing instructions to the operator and also asks for answers to the questions it presents.

Although the LOGMOD set weighs only about 20 pounds, it can store detail logic of aircraft systems that contain thousands of parts, keep track of how each part functions and relates to every other part, and operate at a speed with accuracy far beyond that of any individual.

A logic model of an entire aircraft can be put together to fault-isolate malfunctions ranging from the black-box level to modular level to piece-part level. Thus, a maintenance manual is rarely, if ever, required.

LOGMOD was operated successfully in December 1976 and three months later was demonstrated on a 6-foot scale-model of a Cobra helicopter to show how electronic and mechanical design features can be fault isolated. The scale-model Cobra, which was flown at speeds approaching 100 mph, is shown in Fig. 4. It was equipped with more than 300 electronic and mechanical components, yet LOGMOD was able to spot every fault for any combination of manually induced malfunctions, and these tests were performed by persons who had never seen the helicopter or the LOGMOD Set.

Army research to date has been performed in-house by the Advanced Systems Research Office and under contract with Detex Systems, Inc., Orange County, CA. Mr. Bill Andre, Dr. James Wong and Mr. Mike Kodani served as the in-house research team, and Mr. Ralph DePaul and Mr. Larry Dingle have been the contract principals.

Last year the Air Force Logistics Management Center (AFLMC) established an Air Force LOGMOD Project Office to conduct an evaluation of the LOGMOD application to the AN/APN-147 doppler radar system used on the Air Force C-141 aircraft. A fundamental mathematical result of the LOGMOD theory and the unique design features of the set allow it to adapt to different systems with no hardware changes to LOGMOD.

This feature enabled the Air Force to conduct evaluations with the same set that the Army uses on helicopter systems. Air Force experiments are being conducted at Norton AFB under the direction of MAJ Billy Lacey, AFLMC, with contract funding from the Air Force PRAM Office at Wright-Patterson AFB. Technical responsibility is with the RTL.

According to the Air Force Test Plan, it is planned to compare the LOGMOD approach with existing maintenance procedures and also with other types of troubleshooting aids which the Air Force Human Resources Laboratory recently investigated. The doppler radar was chosen as the test system because it is fairly complex and a data base for comparison is available.

The Naval Electronics Command, through the Naval Underwater Systems Center and the Recon Electronic Warfare Systems Navy (REWSON) Activity, initiated evaluation efforts of LOGMOD on special underwater surveillance gear identified as BRD-7. This system contains dozens of racks of electronics aboard submarines and is considered to be extremely difficult to maintain and troubleshoot.

The Navy requirement for a small portable test set that can be carried through a submarine hatch is answered by



Fig. 4. COBRA Scale-Model Used for LOGMOD Tests  
LOGMOD. Because of the ability to store extensive logic information on small floppy disc units, the entire BRD-7 system logic can be contained within the LOGMOD unit.

The Naval Equipment Training Center at Orlando, FL, has investigated LOGMOD as an aid in providing training and equipment demonstrations. The maintenance training implication of LOGMOD can be significant in the in-depth tutoring for learning effective repair strategies. Rapid simulation of a variety of failures and combination of failures provides faster training compared to classroom lectures or on-the-job training.

MIRADCOM plans to use LOGMOD to inspect missile electronics hardware down to the card or board level. This is oriented towards production-line inspections to assure efficient operations and permit easy tests and corrections on a production line or manufacturing basis at depot levels. Results of the AFLMC tests at Norton Air Force Base on the AN/APN-147 will be used by MIRADCOM to help evaluate this area of application.

In light of the wide interest shown for the LOGMOD technique by all three services, RTL, AVRADCOM, will continue with engineering investigations to explore and evaluate this technology.

Plans include contract work to apply LOGMOD to the M28 gun turret on the AH-1 helicopter in coordination with the Cobra Program Manager, Training and Doctrine Command (TRADOC), Army Armament Readiness Command (ARRCOM) and the 7th Infantry Division at Fort Ord, CA, which requested the M28 evaluation. The 2110 Air Cavalry, 7th Infantry Division and the 155th Attack Helicopter Company, Combat Development Experimentation Command, are supporting the M28 evaluation at Ord.

Technology transition from the Advanced Systems Research Office to RTL's Applied Technology Laboratory, Fort Eustis, VA, will be conducted in the near future to support other technology applications and address further user evaluation with TRADOC.

*WILLIAM L. ANDRE, research engineer and technology program manager in the areas of aircraft weaponization, nondestructive testing, and reliability/maintainability, joined the Advanced Systems Research Office of RTL in 1972, and prior to that worked for the Weapons Command at Rock Island Arsenal. He holds an AA degree in general engineering from Harbor College, Los Angeles, a BS degree in mechanical engineering, Louisiana State University, and MS degree in mechanical engineering, Texas A&M University, and the Army Certificate in Maintainability Engineering. Mr. Andre formulated the Logic Model Concept for aircraft systems shortly after joining RTL in 1972.*

