# TESTING FULLY TESTABLE SYSTEMS: A CASE STUDY

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Testability is a measure of the potential to evaluate performance, determine operability, or identify faults within a system. Testability must be coupled with a strategy by which it is used to achieve field maintainability. It is often difficult to distinguish between shortcomings in testability and shortcomings in diagnostic strategy; however, adequate levels of both testability and diagnosis are required. An analysis of the Blackhawk helicopter illustrates the importance of matching the maintenance procedures to the maintenance architecture and the mission requirements.

The Blackhawk Stability Augmentation System (SAS), is a subsystem of the Automatic Flight Controls System (AFCS). The AFCS is a system that provides inputs to the Flight Control System to assist the pilot in handling the helicopter. The AFCS includes two other major subsystems in addition to the SAS: the Digital AFCS and the Stabilator System. Together, the three subsystems provide oscillation damping and maintain desired altitude, speed, and heading. The SAS provides short-term correction and rate damping in the pitch, roll, and yaw axes. It also provides limited altitude hold in the roll axis.

Failure data revealed that the SAS problems constituted 8% of the total Blackhawk maintenance actions but consumed 16% of the total Blackhawk maintenance labor-hours. From this, we inferred that the SAS was consuming a disproportionate share of the total Blackhawk maintenance labor-hours. In addition, high RTOK rates and a large number of repeat maintenance actions indicated a field testability problem. The analysis goal for the SAS was to locate the testability problems and make recommendations for improvements.

We performed a testability analysis on the SAS in several iterations, starting with the manufacturer-documented test procedures and proceeding to a recommended set of procedures. The analysis revealed that the system fault-isolation capability was 100%! This indicated that the system was fully testable and we should not have seen the fielded problems that were reported.

The SAS troubleshooting procedure required more than 78 tests to fault isolate the system and, after maintenance, to verify the repair and proper operation of the system. Those 78 tests include a limited, incomplete check of the test set itself. The existing troubleshooting procedures required 8-12 hours to perform.

Although the tests provided in the original test procedures should have been adequate to perform organizational-level isolation and repair, we found two indications that the procedures were not being followed. First, the summary data collection system for the Blackhawk indicated that the mean time to perform maintenance on the SAS system was 3.3 hours—well below the 8-12 hours necessary to complete the specified tests. Second, the test signal set (a calibrated signal generation box) was not being kept in calibration.

In interviews, maintenance technicians indicated that they thought the test procedures were overly complex and they did not understand their purpose. The analysis verified that the test procedures were overspecified. The interviews also indicated that the technicians did not trust the test signal set. In response to these problems, the goal of the analysis was changed to modifying the maintenance procedures to reduce their complexity and include failures within the test signal set.

After several intermediate iterations to reduce complexity, the total number of tests was reduced to 24, and the reduced set of tests still maintained 100% unique component fault isolation. Of the 24 tests, only 3-9 are used at any one time to isolate any one component. The revised fault-isolation procedures were field-tested at three army bases. A typical sequence took approximately 1.5 hours. This is in contrast to the manufacturer-provided fault-isolation procedures that took 8-12 hours.

In a time of declining budgets, the concern for maximizing return on investment is magnified. Complex systems are expensive to build, and designing these systems to be testable is critical. Yet failing to properly utilize the designed testability leaves system users in a situation potentially worse than not designing in testability at all, and the dollars spent for design and maintenance have been wasted. Design for testability is not enough. Effective, efficient use of testability is required to maximize the return on DFT dollars.


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