ANALYSIS OF TEST DATA TO IDENTIFY WIRING FAILURE CAUSES AND TRENDS ON US COAST GUARD ROTARY AIRCRAFT

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Abstract

The goal of this paper is to demonstrate the benefits of proactive testing as a means to enhance and improve overall aircraft electrical reliability while concurrently reducing repair costs and repair time within the Coast Guard's aviation depot facility. HH-65 rotary aircraft electrical systems have traditionally been tested without the benefit of examining the wiring failure data. New software allows wiring analyzer operators to systematically collect and store individual electrical failures, repair types, repair time, aircraft zone and aircraft tail number. This data is exported for trend analysis and report generation. Engineering and management then determine if electrical design modifications are required. Often, other improvements become evident, such as enhancements to tooling, training or even documentation. Identifying and locating the root cause of failures is a prerequisite in preventing them which ultimately saves time and cost and increases the aircraft's electrical reliability. The Coast Guard can now anticipate future staffing requirements, training needs, and aircraft repair times. The metrics of collecting and tracking the number of wiring failures, repair types, repair times, aircraft zones, and aircraft tail numbers over time are used to support this claim.

1. Introduction

The Coast Guard has operated the HH-65 as a medium range Search and Rescue (SAR) aircraft since 1986. The aircraft are positioned at various Air Stations located throughout the United States coastal areas, Great Lakes, and Puerto Rico. The HH-65s have traditionally been overhauled at the Aircraft Repair and Supply Center, located in Elizabeth City, NC. During the overhaul process, wiring analysis is performed using DIT-MCO International's, Model 2524 Automatic Circuit Analysis Test Systems (ACATS) equipment to ensure correct wiring configuration. For years, successful wiring analysis was completed on the HH-65 without the benefit of examining the wiring failure data. The ACATS operators used the equipment to locate shorts and opens; however, once the tests and repairs were complete, there was no way to properly collect and track wiring failure data. The benefits of collecting wiring failure data and examining for trend analysis would allow management to identify and locate root causes which is a prerequisite in preventing them and ultimately saving time, cost, and increasing aircraft electrical reliability.

2. Wiring Analysis

Each HH-65 aircraft that is overhauled at the Aircraft Repair and Supply Center is tested with the DIT-MCO ACATS equipment, (Model 2524) with 20K points-of-testing. The wiring analysis consists of eight tests that are combined to verify all airframe, avionics, and Turbomeca Reengining and Upgrade wiring is configured properly. Figure 1 shows a picture of a HH-65 during the wiring analysis process. Aircraft are tested after the electrical buildup and engineering modifications are completed and before the avionics installations. This process consists of eight hours of interface cable hookups and then three hours to run the tests without failures. Wiring failures add additional time for the ACATS operators to

test, find the fault, and then repair. Upon completion of the testing and repair, the ACATS operators systematically enter data associated with the wiring failures through the use of TestStats®.

Figure 1: HH-65 DIT-MCO Testing

3. TestStats®

TestStats® works with the TestExecutive® testing software package. TestExecutive® captures and stores the data from the testing process for future analysis in TestStats® via the component object model (COM) software architecture. TestStats® is a full-fledged relational database management system (RDBMS) which supports Open Database Connectivity (ODBC). There are two versions of TestStats®: TestStats® Pro and TestStats® Lite as shown in Figure 2. With TestStats® Pro, an operator or manager can

Figure 2: TestStats® Versions

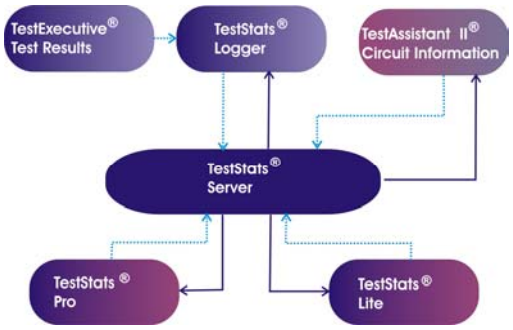


Figure 3: Test Results to TestStats® Logger to TestStats®

run reports, develop graphs and provide statistical analysis of the wiring failure data. Also, operators can update individual product test results. TestStats® Lite offers limited functionality. Operators can enter causal codes and disposition codes from a variety of locations as shown in Figure 3. Also, TestExecutive® does not have to be installed on the computer with either TestStats® Pro or TestStats® Lite.

4. Data Collection

Operators use the TestStats® Test Results Summary interface as shown in Figure 4 to enter wiring failure data for previously saved testing results. The Test Results Summary dialog page contains three panes. The Product File Pane contains information about the selected test sequence number. It includes items such as product file name, results type and test start and completion times/dates. The Repair

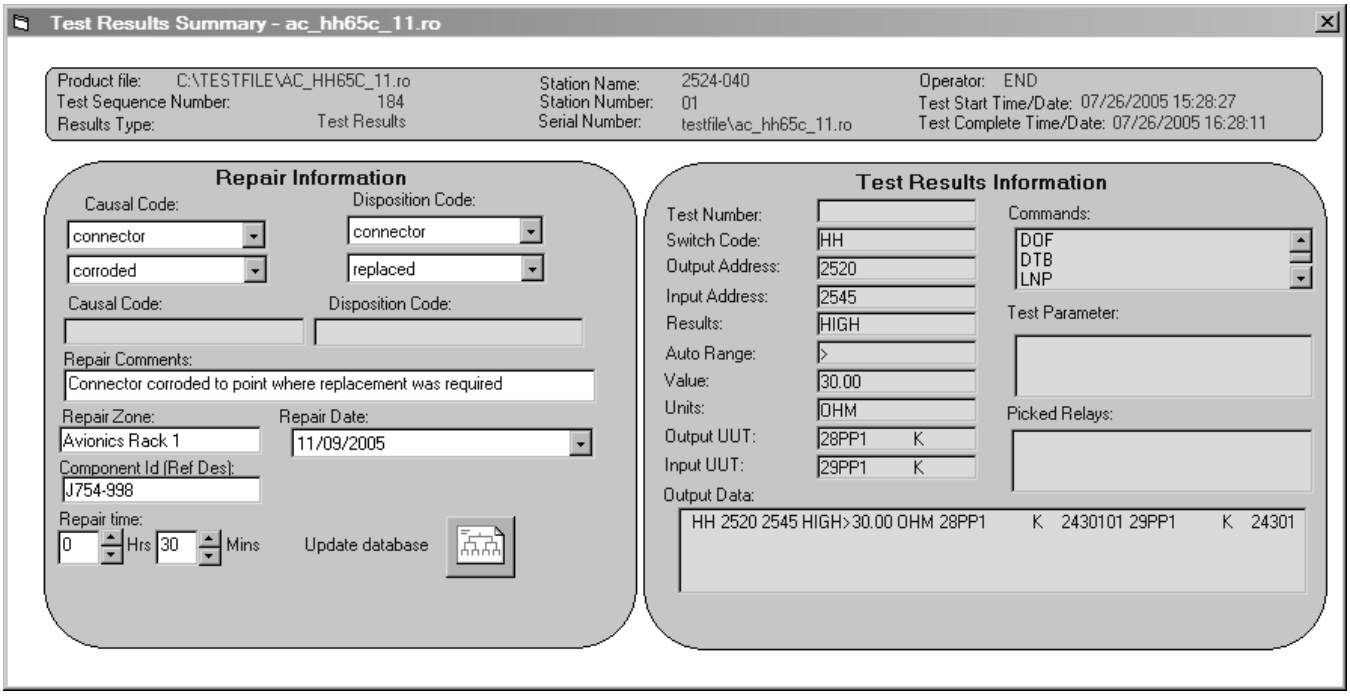


Figure 4: Test Results Summary Interface

Information Pane includes the following data: Causal Code, Disposition Code, Repair Comments, Aircraft Zones, Repair Date, Component ID, and Repair Time. Pull-down menus are used to collect the Causal Code, Disposition Codes, and Repair Time to increase accuracy of the data and to lessen the impact to the operator. The impact to the operator should be no more than one minute per wiring failure for data entry. Causal Codes pertain to the condition responsible for a test result. Pull-down menus include two Causal Code lists that are frequently used. These lists are shown in Chart 1. The left Causal Code list pertains to the component name and is the noun, while the right list indicates what type of problem has occurred and is the verb. Disposition Codes pertain to the repair action that was taken to

Noun	
Circuit	Lug
Circuit Breaker	Pin
Clamp	Relay
Coax Cable	Shield
Connector	Splice
Ground	Switch
Harness	Term Block
Insulation	Wire

Verb	
Bent	High Resistance
Broken	Over Heated
Chafed	Missing
Contaminated	Not Locked
Corroded	Not Grounded
Crimp Improper	Routed Wrong
Cut	Shorted
Damaged	Wired Wrong
Faulty	In Question

Chart 1: Causal Codes

fix the wiring failure. Pull-down menus are also included for the two Disposition Code lists that are frequently use. They are shown in Chart 2. The left Disposition Code list pertains to the component name and is the noun, while the right list indicates the repair that occurred and is the verb. The Aircraft

Noun		Verb	
Circuit	Lug	Cleaned	Spliced
Circuit Breaker	Pin	Corrected	Tightened
Clamp	Relay	Installed	Notified
Coax Cable	Shield	Repaired	Ordered
Connector	Splice	Replaced	
Ground	Switch	Rerouted	
Harness	Term Block	Reseated	
Insulation	Wire	Soldered	

Chart 2: Disposition Code

Zone Codes, shown in Chart 3, consist of 17 zones developed by the HH-65 operators to distinguish areas of the aircraft by wiring versus structure. The Test Results Information Pane as indicated, contains test

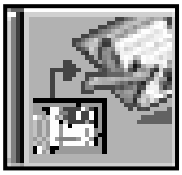
1. Nose Compartment / 1 Alpha Panel
2. Instrument Panel / 8 Alpha Panel
3. Center Console / 2 & 3 Alpha Panels
4. Center Pedestal
5. 4 Alpha Panel
6. 5 Alpha Panel
7. Cockpit Overhead / 12 Alpha Panel
8. Cabin
9. Baggage Compartment
10. Left Chine Panel
11. Right Chine Panel
12. 23 Alpha Panel
13. 24 Alpha Panel
14. Tail Cone / Fenestron
15. Transmission / Engine Deck
16. Wheelwells / Aircraft Belly
17. Avionics Rack / Avionics CB Panel

Chart 3: HH-65 Aircraft Zones

results information. The pane contains Test Number, Switch Code, Output/Input Address, Mnemonic, Value, Units, Input/Output UUT, Active Modes, Test Parameter, Picked Relays, Auto Range, and Output Data.

5. Data Analysis

Once the data has been collected in TestStats® it is exported to Microsoft® Excel, then Excel is used to analyze and chart the data in a variety of ways. The types of data that can be generated are limited only by your own imagination. By having all the data in Microsoft® Excel, you use familiar tools for generating specific charts and statistics as required. Additional statistics can be reported using statistical functions in Microsoft® Excel. In order to fully utilize TestStats®, a manager must be familiar with advanced spreadsheet and database functions such as macros and SQL. They also must have a firm understanding of ODBC technology. When the Export to Excel button (shown below) is selected, the Microsoft® Excel workbook, shown in Figure 5, opens. TestStats® also exports data to statistical



Microsoft Excel - Book1

File Edit View Insert Format Tools Data Window Help

A1 ProductSequenceNumber

	A	B	C	D	E	F	G	H	I	J
1	ProductSequenceNumber	Test Status	Start Date	Start Time	Complete Date	Complete Time	Operator ID	Serial Number	Config ID	
2	33	2	6/5/2003	14:48:33	6/5/2003	14:48:46	undefined	13	4	
3	34	2	6/5/2003	14:49:00	6/5/2003	14:49:33	undefined	14	4	
4	35	5	6/5/2003	14:54:11	6/5/2003	14:56:13	undefined	15	4	
5	36	2	6/5/2003	14:56:21	6/5/2003	14:56:34	undefined	13	4	
6	37	2	6/5/2003	14:57:04	6/5/2003	14:57:07	undefined	16	4	
7	38	2	6/5/2003	14:57:22	6/5/2003	15:00:11	undefined	17	4	
8	39	5	6/12/2003	10:15:22	6/12/2003	10:19:48	undefined	13	4	
9	40	5	7/25/2003	13:29:49	7/25/2003	13:30:35	undefined	15	5	
10	41	5	7/25/2003	13:37:45	7/25/2003	13:38:12	undefined	15	5	
11	42	5	7/28/2003	15:59:22	7/28/2003	15:59:28	undefined	14	5	
12	43	1	7/28/2003	16:02:23			undefined	14	5	
13	44	1	7/28/2003	16:05:51			undefined	14	5	
14										
15										
16										
17										
18										
19										

TESTTABLE TRTABLE NTRTABLE MODESTABLE PARAMETERTABLE CONFIGTABLE

Ready NUM

Figure 5: Data Exported into Microsoft Excel

analysis software. TestStats® includes sample Microsoft Excel chart templates to help you construct your analysis tools. See the following examples:

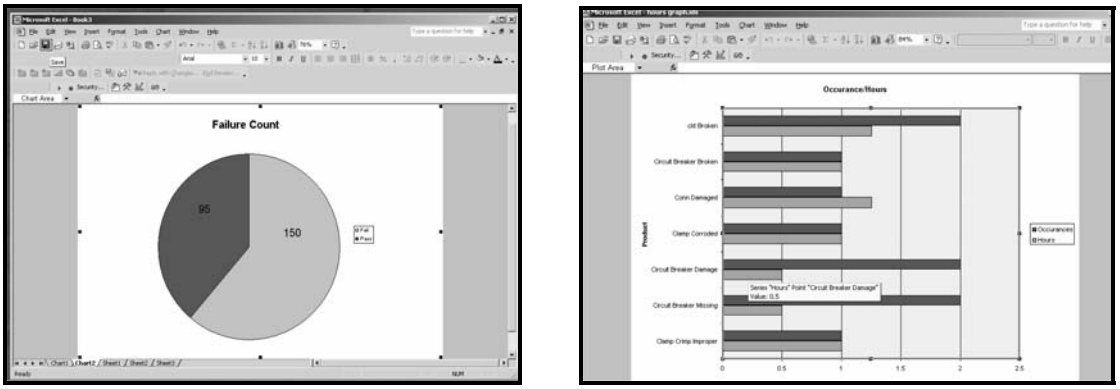


Figure 6: Microsoft® Excel Chart Templates

6. Test Results

The use of TestStats® at the Coast Guard's Aircraft Repair and Supply Center started in October 2005. Since that time, wiring failure data has been collected on seven HH-65s. The tail numbers of these aircraft are: 6509, 6527, 6532, 6534, 6571, 6588, and 6589. Of these seven aircraft tested, the Coast Guard determined that the HH-65s had more wiring failures in the Avionics Rack / CB Panel Zone than any other area. As shown in Chart 4, the most common aircraft wiring failure type was "Connector Wired Wrong". The large number of "Connector Wired Wrong" failures can be attributed to the ongoing Turbomeca Reengining and Upgrade efforts. The average number of failures per aircraft was 126 and the average time for repair of these wiring failures per aircraft was 58.5 hours. From examining this data, the Coast Guard will now focus more attention and inspections in the Avionics Rack Zone of the HH-65s during upgrades and depot maintenance. By examining the data for trend analysis, the Coast Guard can now anticipate future staffing requirements, training and tooling needs, and aircraft repair times. For the case of connectors being wired wrong during depot maintenance, either better training is needed or wiring manuals are not up to date. The next largest failure type was corroded connector. The data shows that the majority of these failures where located in the Wheelwell and Tail Cone zones. By using the

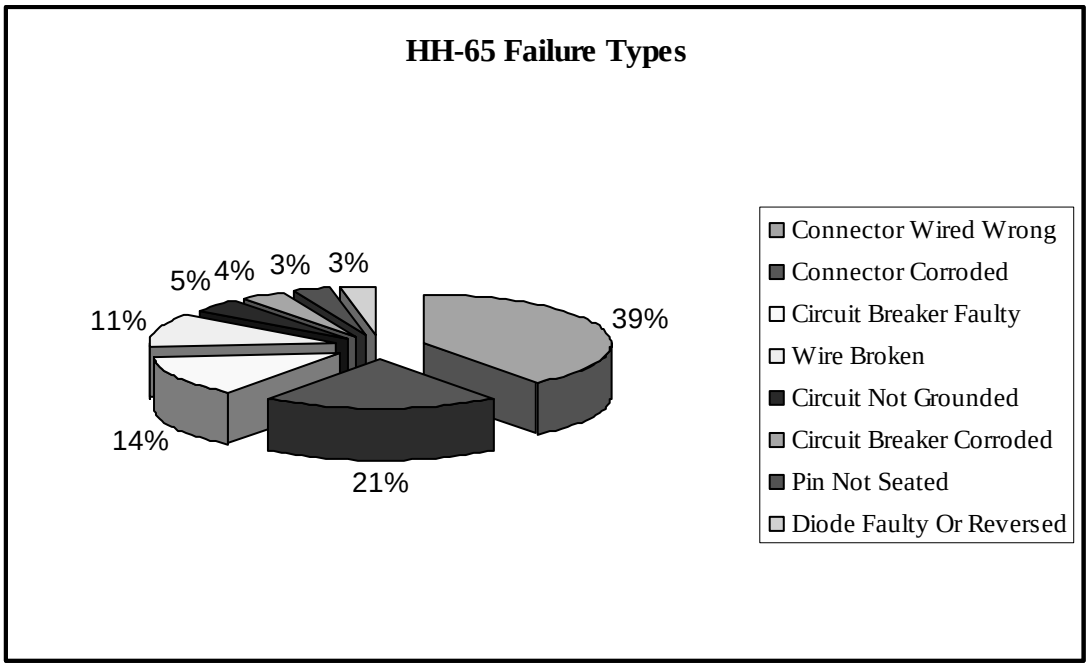


Chart 4: HH-65 Failure Types

TestStats® data, maintenance personnel can better understand where corrosion inspections and better prevention need to be performed. Better planning for aircraft depot repair time and staffing requirements can eventually be determined by examining the total repair time for each aircraft over a period of time. Not only is this a savings to the depot in time and money; it also provides the Air Stations a more electrically reliable aircraft. This means the Coast Guard will be successful in performing its mission within Homeland Security. Future plans at the Aircraft Repair and Supply Center include the use of TestStats® to collect and track aircraft wiring failure data on the HC-130, HU-25, and HH-60T.

7. Summary

TestStats® has allowed Coast Guard management and engineering to obtain data for continued aircraft improvements, enabled the analysis of wiring data, highlighted recurring problems so corrective action can be developed and implemented, provided prognostic information to correct faulty design processes, and reduced large quantities of data to meaningful reports that can be used to make a decisions. Using this proactive testing tool to identify and locate the root cause of failures has been and will continue to be a prerequisite in preventing wiring failures which ultimately saves time and cost and increases the aircraft's electrical reliability

*** Note**: Test Results may be slightly different for the Aging Aircraft Conference presentation due to the continued collection of HH-65 wiring data.