DIAGNOSTICS INTEGRATION - A TAC MAINTAINER'S VIEW

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ABSTRACT

When one hears the term "integrated diagnostics," it is usually associated with Built-in Test (BIT). But from the TAC maintainer's view, integrated diagnostics is the total effort, beginning with fault reporting, troubleshooting, repair; and ends with modification to correct the physical cause of failure. In order to understand where the user wants to go with diagnostic integration, we must understand where we are now, what impact it has on our world, and what we believe can be done to achieve the desired results.

There are several factors that limit diagnostic capability today, beginning with integrated BIT. It is a given that on board testability has not been a "designed in" but rather an "added on" feature. Technology hasn't been there to allow up-front design for testability in the past; hence testability came after performance, although a maintainer finds it hard to separate the two. Limited on board memory availability, processing capability, and dollars relegated testing capability to "whatever is left."

In many cases, testability that was available initially was traded away as operational requirements grew to consume more of the limited processing and memory allocation. That's just the physical limitation; there are several other missing pieces of information that hamper "real" diagnostics integration.

We haven't a method today to relate a detected system fault to the environment in which it occurred. Why is this important? Any failure of any system, component or assembly is the result of the physical properties of the failed material. Quite simply, it couldn't take the vibration, G force (stress), temperature in degree or rate of change, etc. Without this time, stress, and measurement data (TSMD), the environment is not accurately defined. Thus, the physical cause of failure is left undetermined. Only the symptoms of the physical failures are recorded; i.e., "the radar did not lock on."

In addition to lack of environmental definition, there is a lack of integration between an aircraft system failure and subsequent I and D-level test programs.

What integration today's systems do employ is limited to the aircraft system. There is a lack of "vertical failure information accountability." What does this mean? Aircraft BIT is normally a functional test relating to modes of operation, while I-level and D-level tests are of parametric design; thus, mode specific failure data from the aircraft is lost at the aircraft. A unit removed from an aircraft for a specific failure is end-to-end tested, and any repair associated with its parametrics is considered a valid repair whether or not it relates to the failure on the aircraft. This topic will be discussed further in the discussion of impacts.

Finally, the logistics information system, i.e., maintenance data collection (MDC) system, as it is currently structured, does not relate the mode specific failure with I or D-level parametric tests results; nor does it have the capability to accept TSMD if it were available.

In order to understand the impacts of this lack of integration, let's look at a current weapons system that has a fairly good BIT, an I-level and D-level test capability, apply the problems outlined, and assess the total effects.

The current fighter aircraft form a classic example of the shortfalls in total integrated diagnostics. This is by no means an attack on the aircraft contractors or the Air Force, but rather an assessment of the problems we both face in developing true integration.

The BIT detects faults by a matrix of on board test failures that are summed and translated via the Fault Reporting Manual to create a mode specific fault code. Although the test failure data is available digitally on the Mission Data Cartridge, it is manually summed during debriefing. Once summed and translated to a fault code, the information leads the technician to a fault isolation tree in the Fault Isolation Manual. Since TSMD is not available, there is no accurate way to relate the fault to the environment. In many cases, the isolation procedure leads the maintainer to an ambiguity group. For the sake of discussion, we will assume an ambiguity group of three Line Replaceable Units (LRUs) of the radar. The ambiguity is a result of memory space and processing capability shortfalls, as discussed earlier. Once isolated to the ambiguity group, the pressures of operational need come into play. If the technician is time constrained to meet a sortie requirement, he will elect to remove and replace all three units rather than lose the sortie to lengthy troubleshooting.

The three units are then tagged and sent to the I-level for test. It is at this point that the "vertical" information flow breaks down. The mode specific failure data is converted to generalized MDC data. The I-level technician receives three units tagged as "failed to operate - specific reason unknown" (HOW MAL 242). The units are tested end-to-end on the automatic test station and parametric failures are repaired. Let us assume that one unit actually caused the failure and is repaired; however, the other two units had failures, as simple as a light driver failure, that in no way contributed to the original aircraft radar detected fault. Neither unit is coded as a could not duplicate (CND) or retest OK (RTOK). To this point, we've witnessed "swap tronics," a higher than necessary demand rate and have possibly induced failures by excessive removal and installation of parts in the aircraft (three LRUs, two of which were good). What's the result? Let us present some general figures to make the point. Avionics LRUs during one period showed a 61.1% repair rate, a 26.7% RTOK and a 12.2% not repairable this station rate.[1] The sad truth is "we don't know what the real repair and RTOK rate was because we have no way to relate the I-level test failures to the flight line faults! Yes, we repaired 61%, but did we have to when we did, or did we fix parametric problems that would not have affected aircraft system performance for many more flying hours? Without knowing the environment and the I-level test that fixed the fault, and why (vertical accountability), we can't "grow" the diagnostics to eliminate the problem of ambiguity! Additionally, we have failed to give the engineer adequate feedback (fault, environment, repair) information from which to design out the failure mode experienced. What approach can we take to fix the problem and do a better job?

First and foremost, testability must be considered a major factor in performance and designed in from the beginning phases of development. With the advent of distributive architecture, fault tolerant design, and reconfigurability, test becomes a primary focus of operation and, thus, technology and operational requirements may well have resolved that part of the problem. More, however, is needed.

Built-in Test must be integrated and automated into the technical data systems employed by the maintainer, at all levels, O-, I-, and D-. To that end, industry and government should develop a unified failure reporting system that links vertically the on board fault with all levels of repair action and bookkeeps repair in categories of failures by the physical nature of the failure within the environment in which it failed. To do this, TSMD must be designed in and captured along with the failure data.

Finally, the maintenance data collection system needs to be overhauled to accommodate the capture and feedback of fault codes, TSMD, fault specific and non-fault specific repair action. How would a system like this function and what would we gain?

Again, let us use a current fighter as an example. Automated fault information is down loaded into a revamped MDC/technical data system where fault codes are generated and fault isolation procedures are selected and presented to the maintainer. The current DOD Std 863B/MIL-M-83495 Fault Reporting and Fault Isolation Manuals provide an excellent tool for automation as fault codes and isolation procedures are logically and sequentially numbered. Using the radar example, the fault code would be 94-61-XH which means weapons control-radar-air-to-air mode - "failed to lock on." The isolation procedure is JG (job guide) 94-61-001 which means for fault 94-61-XH, start here. The final action would be JG 94-61-005 which means remove and replace low power RF assembly and dual signal processor. (That flight line information would be automatically relayed to I-level, and automatic Test Program Set (TPS) test numbers would be matrixed to look for a parametric failure which would cause that particular system failure mode.) Repair action would be taken and logged and tagged to the system fault code and the captured TSMD.

All non-fault code related parametric failures would be logged, but recorded separately. All data would then be transferred to engineering at depot and/or contractor for trend and analysis. Data would then be studied and applied to define the exact physical cause of failure relating to the physical properties of the failed component within a specific environment. By this method, trending could be developed and definition of time to failure for specific types of equipment could be established. Simply put, we could begin to define the knee of the failure curve, much the same as we do

[1] Isolation of Faults in Air Force Weapons and Support System, Committee on Isolation of Faults in Air Force Weapons Systems, Air Force Studies Board, Summer 1986

for airframe structures. Properly applied, prognostics could be directed to the field and critical failure of aircraft systems could be preempted. Information gained would be used to eliminate the ambiguity by upgrading the fault isolation procedure or BIT and eventually designing out the failure mode.

Is all this possible? We believe it is. With concentrated effort on the part of industry and government, we can begin to take advantage of technology and automation to bring about a truly integrated diagnostics system that ties design, operation, maintenance, and redesign into a growth system that results in an aircraft that flies and fights and allows the maximum operational capability with the minimum of maintenance effort.