Intermittent Fault Detection and Isolation System (IFDIS) Assessment History

Intermittent Fault Detection Project

Contract # IDIQ GSA ITSS ID05140071011/ Task Order 12

Prepared for:

Air Force Life Cycle Management Center/
Product Support Engineering Division

Submitted by

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Executive Summary

Problem Statement

In 2009, through a Small Business Innovative Research contract, the depot at Hill AFB purchased an Intermittent Fault Detection and Isolation System (IFDIS) from Universal Synaptics to use on the F-16 Modular Low Power Radio Frequency (MLPRF) unit.

There is concern that the purchase of IFDIS by Hill AFB did not follow the DoD acquisition process and as such, IFDIS may not have been the optimal solution.

Since IFDIS is a Commerical off the Shelf (COTS) acquired solution, it was not developed under a traditional DoD Acquisition Process. All the decisions related to bringing IFDIS to market were commercial decisions by the manufacturer. This report examines the decision points the government makes when procuring a COTS solution:

- Was there an identified need?
- Were requirements established?
- Was an Analysis of Alternatives considered?
- Does the select solution satisfy the requirements?

The objective of this paper is to review reports and briefings related to IFDIS and determine if the decision points for COTS solutions were met or otherwise satisfied. Even though IFDIS is in use by both military and civilian organizations, this report focuses only on DoD related documents.

Project Objective

The Air Force Lifecycle Management Center, Product Support Division (AFLCMC/EZP) is committed to technology insertion across the Air Force (AF) sustainment community in an effort to modernize depot operations. This particular project addresses the AF's inability to accurately identify, isolate, and repair intermittent faults of aircraft avionics Line Replaceable Units (LRUs). One such device to identify intermittent faults is a commercially available Intermittent Fault Detection and Isolation System (IFDIS). Although IFDIS is able to identify intermittent faults, the AF Enterprise has not adopted this technology. ALFCMC/EZP is championing this effort to determine why this technology is not used in the AF, address those concerns, and if desired, implement the intermittent fault detection capability.

Results

There is no doubt that IFDIS was originally procured by Hill AFB with the desire to improve readiness and deliver a better product to the warfighter. It is also clear that traditional acquisition processes were not followed however procurement gates were met in a combination of government and contractor actions.

Was there an identified need?

Yes - The briefing by Mr. John Johns, Deputy Assistant Secretary of Defense for Maintenance established the monetary cost of the No Fault Found (NFF) problem[1]. A significant portion of the maintenance budget is spent on removing, shipping, testing, reshipping, and reinstalling components for issues that cannot be duplicated. In addition, the Navy, as the lead agency on the Joint Intermittent Tester working group, identified several components that have a high rate of NFF[2].

Were requirements established?

Yes - Military Performance Specification 32516[3] defines the functional requirements for an intermittent fault detection and isolation system, the environment in which it must operate, and interface and interchangeability characteristics.

Was an Analysis of Alternatives considered?

Yes –An Analysis of Alternatives was conducted in two ways. From a capabilities perspective, several vendors that claimed to have a solution that meets the requirements were evaluated[4]. From a Return on Investment and Cost Benefit Analysis documents[5] [6], the use of IFDIS was shown to be the more economical solution.

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[1] Giles Huby, "*US Defence Dept targets billion dollar NFF savings"*, Copernicus Technology,05 November 2015, para 3, *http://www.copernicustechnology.com/index.php/about-copernicus-technology/news/158-usdod-billion-dollar-nff-savings-target*

[2] Troy Bayer. *JIT (Joint Intermittence Tester) Naval Aviation Enterprise (NAE) Future Readiness Initiative POM17 Return on Investment (ROI) Analysis*. Report. 4.2 Cost Analyst, 4 August 2014, 10

[3] United States. *MIL-PRF-32516 Performance Specification Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths*. By Naval Air Warfare Center Aircraft Division, 23 March 2015, 3-7

[4] National Center for Manufacturing Sciences, *Joint Intermittence Testing (JIT) Capability – Phase II Final Repor*t. Report. December 2016, 14-16

[5] Ogden Air Logistics Complex Acquisition Cost Division, *G3TL12 F-16 Programmable Signal Processor (PSP) Intermittent Fault Detection and Isolation CIP Economic Analysis,* Report, December 2012, 18

[6] Troy Bayer, *JIT (Joint Intermittence Tester) Business Case Analysis (BCA) Analysis of Alternatives (AOA)*. Report. 4.2 Cost Analyst. 19 September 2013, 9

Does the select solution satisfy the requirements?

Yes – The National Center for Manufacturing Sciences, on contract to NAVAIR evaluated several vendor offerings against MIL-PRF 32516 and IFDIS "was the most capable tester of all the systems showcased" and passed all IFE testing[7].

Conclusion

The review of the literature shows that there was an identified need for an intermittent fault detection and isolation system in the Air Force as well as in the Navy. Requirements were established, an Analysis of Alternatives conducted, and IFDIS from Universal Synaptics met those requirements. There is no indication that further evaluations would invalidate the findings.

[7] National Center for Manufacturing Sciences, *Joint Intermittence Testing,* 15

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1.0 Introduction/Background

1.1 Problem Statement

In 2009, through a Small Business Innovative Research contract, the depot at Hill AFB purchased an Intermittent Fault Detection and Isolation System (IFDIS) from Universal Synaptics to use on the F-16 Modular Low Power Radio Frequency (MLPRF) unit. IFDIS continuously monitors all electrical connections while at the same time, subjecting the unit under test to the same thermal and vibration environment as in operation. IFDIS is discounted by some because of the belief that the Hill AFB purchase of the system did not adhere to the traditional DoD acquisition process as shown in Figure 1

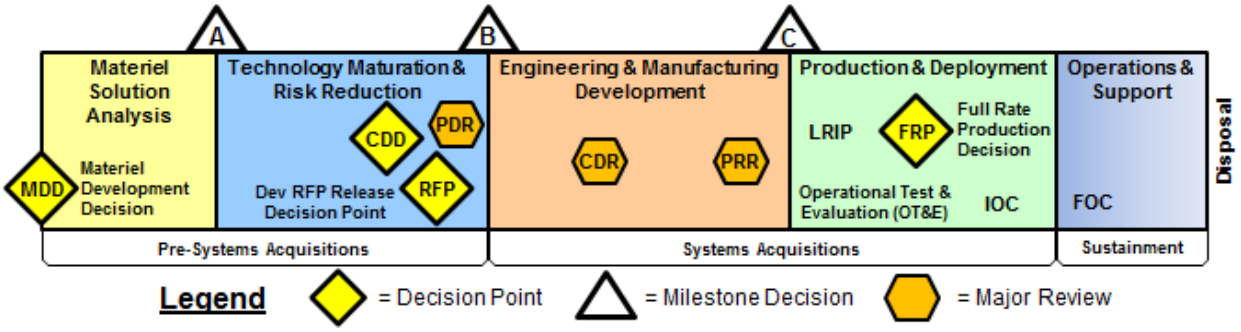

Figure 1 DoD Acquisition Process

The process begins with a stated need and initial capabilities document in the Material Solution Analysis Phase, through fielding in the Operations and Support Phase. Criticism focuses on the early phases of the acquisition process where requirements are established, analysis of alternatives generated, and an evaluation of the solution against those requirements is conducted.

Since IFDIS is a COTS solution, it was not developed under a traditional DoD Acquisition Process. Consequently, all the decisions related to bringing IFDIS to market were made for commercial reasons by the manufacturer. This report examines the decision points the government makes when procuring a COTS solution.

Note: Universal Synaptics has two products; Intermittent Fault Detection and Isolation System (IFDIS) and NCompass Voyager™. The fault detection technology is identical with the difference being that IFDIS includes an environmental chamber.

1.1 Questions Considered

Was there an identified need? A need may be directed from senior leaders or generated from the user community. Is there a need for this technology and what issue is being addressed?

Were requirements established? Once a need has been identified, the government must establish specific requirement in order to proceed. These requirements guide the evaluation of solutions.

Was an Analysis of Alternatives considered? When procuring a COTS solution, it is rare that there is only a single vendor for that solution. An analysis of alternatives evaluates not only different solution providers, but also different courses of action.

Does select solution satisfy the requirements? Has the selected solution been measured against the requirements and if so, how well does the solution meet those requirements? This step evaluates the effectiveness of the solution against the requirements.

The objective of this paper is to review published works related to IFDIS and determine if the acquisition process gates were met or otherwise satisfied. Even though IFDIS is in use by both military and civilian organizations, this report focuses only on DoD related documents.

1.2 Project Description

The Air Force Lifecycle Management Center, Product Support Division (AFLCMC/EZP) is committed to technology insertion across the Air Force (AF) sustainment community in an effort to modernize depot operations. The aircraft maintenance community is faced with situations where avionics Line Replaceable Units (LRU) fail while onboard an aircraft but subsequently pass all standard bench tests when removed from the aircraft. This No Fault Found (NFF) problem costs the DoD between $2 to $10 billion dollars annually and adversely impacts Air Force mission readiness. The majority of NFF issues are attributed to intermittent faults that manifest for extremely short periods (micro- or nano-seconds) and often only occur when the LRU is subjected to the extreme temperature and vibration environments of operational aircraft.

The AF does not have an effective way of accurately identifying and isolating intermittent faults in avionic LRU. NFF due to intermittent faults is a long standing problem that plagues avionics LRU repair. Intermittent faults are frequently caused by cracked solder joints, loose crimp connections, loose wire wraps, corroded contacts, sprung connector receptacles, non-soldered/cold soldered connections and the like on backplane, connectors and/or LRU junction boxes. These LRUs frequently exhibit built in test failures and performance degradation while in flight, however in a back shop or Depot environment, these units often pass all standard tests, resulting in a NFF. The impact of non-resolved intermittent faults is wasted man-hours troubleshooting LRUs, increased aircraft maintenance cost due to continually removing and replacing LRUs. There is also increased cost to procure and sustain greater number of LRUs in order for the supply chain to compensate for low mean time between failures (MTBF), etc. NFF is a $2B - $10B annual non-value added expense to the DoD each year.[8]

In light of an intermittent fault problem on the F-16 Modular Low Power Radio Frequency (MLPRF) LRU, in 2008 Hill AFB procured an IFDIS test platform[9], manufactured by Universal

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[8] OSD/OUSD ATL, Director, Enterprise Maintenance Technology OSD Maintenance Policy and Programs, 24 Oct 17.

[9] Intermittent Fault Detection & Isolation System (IFDIS™) *Neil Starling* - *http://www.usynaptics.com/index.php/products/ifdis* accessed 15 Mar 18.

Synaptics. IFDIS combines continuous high-resolution monitoring of every electrical path in an LRU chassis and features an environmental enclosure that heats, cools, and vibrates the LRU under test, thereby mimicking the in-flight conditions that manifest the intermittent faults.

However, the IFDIS is not included in the standard maintenance test procedures for the depot. That along with isolated skepticism of IFDIS effectiveness has resulted in resistance to adopt this new technology.

IFDIS is a commercial system that has been evaluated numerous times for the Department of Defense. This document reviews those evaluations, identifies who conducted them, provides a summary, and, in the end, draws a conclusion as to the completeness of the documentation against the project objective to determine if the acquisition process gates were met or otherwise satisfied.

2.0 Establishing Need

Was there a need identified for this system.

2.1 Cost of No fault Found

2.1.1 Reference Information

Title: AUTOTESTCON 2015 Military Keynote Speaker

Date: November 2015

Author: Mr. John Johns, Deputy Assistant Secretary of Defense for Maintenance

2.1.2 Summary

This reference establishes the cost of intermittent faults.

As Deputy Assistant Secretary of Defense for Maintenance, Mr. Johns oversaw the DoD $80 billion equipment and weapons maintenance program. In a presentation at AutoTestCon in 2015, Mr. Johns stated “[the US government] spend[s] $2 billion annually on removing and processing subsystems with ‘No Fault Found’”[10].

2.1.3 Conclusion

Establishes the need. The reference establishes the need for an intermittent fault detection system by quantifying the cost of the No Fault Found problem within the US Government. This establishes the economic need to address the No Fault Found problem.

[10] Huby, “*US Defence Dept targets*”, para 3

3.0 Establishing Requirements

3.1 Document: MIL-PRF-32516 Performance Specification[11]

3.1.1 Document Information

Title: MIL-PRF-32516 Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths

Date: March 2015

Author: Naval Air Warfare Center Aircraft Division

3.1.2 Summary

This Performance Specification indicates a classification for diagnostic equipment based on the category of intermittent faults that it detects. The following categories are defined:

- Category 1. Short duration intermittent faults that are under 100 nanosecond duration across all LRU/WRA backplane circuits and associated wire harnesses.
- Category 2. Intermediate duration intermittent faults that are 101 nanosecond to 500 microsecond duration across all LRU/WRA backplane circuits and associated wire harnesses.
- Category 3. Long duration intermittent faults that are 501 microsecond to 5 millisecond duration across all LRU/WRA backplane circuits and associated wire harnesses.

The specification defines the environment in terms temperature, humidity, altitude, vibration, etc. that the test equipment must endure and still operate correctly. This specification contains testing guidance in the following appendices:

- Appendix A Vibration Stimulation
- Appendix B Temperature Stimulation
- Appendix C Temperature/Vibration Stimulation

3.1.3 Conclusion

Establishes the requirements. This document establishes the performance specification for an intermittent fault detection and isolation electronic test equipment. This establishes the requirements that a test unit must meet.

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[11] United States. *MIL-PRF-32516 Performance Specification*

4.0 Establishes Analysis OF Alternatives

4.1 Hill AFB Economic Analysis[12]

4.1.1 Document Information

Title: Hill AFB, Utah G3TL12 F-16 Programmable Signal Processor (PSP) Intermittent Fault Detection and Isolation System (IFDIS)

Date: December 2012

Author: Ogden Air Logistics Complex Acquisition Cost Division, OO-ALC/FZC

4.1.2 Summary

This document provides an economic analysis of the IFDIS as a test mechanism for the F-16 Programmable Signal Processor (PSP). Based on the results of using IFDIS on the MLPRF LRU, Hill AFB wanted to quantify the expected results of IFDIS use on the PSP.

Specifically, it explores three alternatives:

- Alternative 1 – Continue status quo testing the PSP utilizing the existing equipment.
- Alternative 2 – Procure a new IFDIS system capable of use on the PSP.
- Alternative 3 – Use the MLPRF IFDIS system.

Alternative 3 was dismissed since the number of test connections required to test the PSP is 8,265 and the MLPRF IFDIS is limited to 1,024.

The document concluded that alternative 2 would provide the lower cost to benefit ratio and results in a savings of $2.25 for each $1 invested with a payback period of just under 8 years.

The analysis is based on the opinion of the Hill AFB Avionics Director that IFDIS detects intermittent faults in 70% of the units tested.[13]

4.1.3 Conclusion

Establishes analysis of alternatives. This document provide a source of IFDIS performance along with the project cost savings of using IFDIS on the PSP. This is the earliest evaluation on the cost benefit of IFDIS for the PSP.

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[12] Ogden Air Logistics Complex, *G3TL12 F-16 Programmable Signal Processor (PSP)*

[13] No additional information provided on the source of the 70% figure.

4.2 JIT (Joint Intermittence Tester) Business Case Analysis (BCA) Analysis of Alternatives (AOA)[14]

4.2.1 Document Information

Title: JIT (Joint Intermittence Tester) Business Case Analysis (BCA) Analysis of Alternatives (AOA)

Date: September 2013

Author: Troy Bayer, Naval Air Warfare Center Aircraft Division Lakehurst Competency 4.2

4.2.2 Summary

Establishes analysis of alternatives. The Joint Intermittence Tester Wiring Product Team (WIPT) commissioned this analysis of alternatives with regard to adopting different IFDIS configurations. This study did not look at a specific Weapons Replaceable Assemblies (WRA)/LRU but analyzed the cost of the top fifteen "bad actor" WRA/LRUs for the F/A-18A-F, EA-18G, HH-60H, MH-60R, MH-60S, and the MV-22. A "bad actor" is defined as a WRA/LRU with a high rate of no fault found when testing. The five alternatives considered were:

- Alternative 1 – Continue with status quo, no change
- Alternative 2 – Invest in core Intermittent Fault Detector (IFD) technology (attempt to induce fault with slight tapping on side of WRA)
- Alternative 3 – Invest in core IFD technology plus Vibration Stand (dynamic testing)
- Alternative 4 – Invest in core IFD technology plus Thermal Chamber (dynamic testing)
- Alternative 5 – Invest in core IFD technology plus Vibration Stand plus Thermal Chamber (dynamic testing)

The analysis concluded that alternative 3 (Intermittent Fault Detection system combined with the vibration) had the highest return on investment factor of 12.3. This is a savings of $152.4 million against a cost $12.4 million through FY35.

Alternative 5 (Intermittent Fault Detection system with vibration and thermal chamber) had the second greatest return on investment factor of 11.2, but provided the greatest life cycle savings of $189.9 million against a cost of $17.2 million.

[14] Bayer, *JIT (Joint Intermittence Tester) Business Case Analysis (BCA)*

The analysis was based on “USAF reduced [units declared beyond economical repair] attributed to [no fault found] by 68% by the fielding [depot level] IFD.”[15]

4.2.3 Conclusion

Establishes analysis of alternatives. This document analyzes the return on investment between the various configurations of IFDIS (with/without vibration stand and with/without thermal chamber). The conclusion of the evaluation is that while more expensive, the ability to test thermal and vibration while at the same time continuously monitor all the circuit paths yields the greatest life cycle cost savings.

4.3 JIT (Joint Intermittence Tester) Business Case Analysis (BCA) Analysis of Alternatives (AOA)[16]

4.3.1 Document Information

Title: JIT (Joint Intermittence Tester) Naval Aviation Enterprise (NAE) Future Readiness Initiative POM17 Return on Investment (ROI) Analysis

Date: August 2014

Author: Troy Bayer, Naval Air Warfare Center Aircraft Division Lakehurst Competency 4.2

4.3.2 Summary

This document reports the ROI analysis used to determine whether investing in Common Support Equipment (CSE) that allows for diagnosis and repairs of intermittent failures at the D-level (with potential application at the I-level) will be cost effective to the USN/USMC. This analysis is based on 11 known “bad actors” for the F/A-18.

The document shows that for the 11 WRA/LRUs in question, the USN/USMC will spend $203.84 million on operation and sustainment through FY39. However, investing $10.71 million to procure two IFD systems and 1 portable system, the return on investment would yield a reduction in operations and sustainment cost to $81.49 million through FY39.

This analysis is based, in part, to “applied cost reduction rate of 68% to mirror USAF’s performance data” using IFDIS.

4.3.3 Conclusion

[15] No additional information provided on the source of the 68% figure.

[16] Bayer, *JIT (Joint Intermittence Tester) Naval Aviation Enterprise (NAE)*

Establishes analysis of alternatives. This is the third cost benefit analysis of using IFDIS for testing. In this case, this analysis involved the application of 3 systems to the NFF issues across 11 LRUs.

4.4 Document: Navy's First Intermittent Fault Detection & Isolation System (IFDIS)[17]

4.4.1 Document Information

Title: Navy's First Intermittent Fault Detection & Isolation System (IFDIS)

Date: October 2015

Author: Brett Gardner, Advanced Aircraft Technologies (AAT) Fleet Readiness Center Southwest

4.4.2 Summary

This document reviews an evaluation of the Universal Synaptics IFDIS conducted by the US Navy. As a result of a high NFF rate of the F/A-18 Generator Convertor Unit (GCU), an AAT team visited Hill AFB to observe the MLPRF IFDIS unit. Following that visit, a NAVSUP funded a demonstration test of the IFDIS targeted against the GCU.

The Navy conducted the test at the TQS facility at Ogden and brought five Ready For Use (RFU) GCUs. RFU is a designation given to a WRA/LRU deemed serviceable and ready to install on an aircraft. The IFDIS system detected and isolated one or more intermittent circuits in four of the five (80% GCU failure rate).

As a result of the test, Navy funded the purchase an IFDIS and three separate interface test adapters for the GCU.

4.4.3 Conclusion

Establishes meeting requirements. This documents a deliberate test of the effectiveness of IFDIS against the F-18 GCU. The result that the IFDIS discovered intermittent faults in 80% demonstrates the effectiveness of IFDIS.

5.0 Establish Meeting Requirements

5.1 Joint Intermittence Testing (JIT) Capability – Phase II Final Report[18]

[17] Brett Gardner, *Navy's First Intermittent Fault Detection & Isolation System (IFDIS)*. Report. Advanced Aircraft Technologies (AAT) FRCSW, 27 October 2015

[18] National Center for Manufacturing Sciences, *Joint Intermittence Testing (JIT),* 16

5.1.1 Document Information

Title: Joint Intermittence Testing (JIT) Capability – Phase II Final Report

Date: December 2016

Author: National Center for Manufacturing Sciences

5.1.2 Summary

This report covers a technology demonstration of intermittent fault detection test equipment during the week of 4 January 2017 at NAVAIR Lakehurst. The Department of the Navy issued a Request-For-Information N68335-15-RFI-0505 and six companies responded:

- Dragoon ITCN
- Trimble Sustainment Engineering, Inc.
- Eclypse International
- Universal Synaptics Corporation
- Williams RDM
- Solavitek

Of the six companies, Eclypse International, Universal Synaptics Corporation, and Solavitek, Inc. and a fourth, Ridgetop Group, identified in a previous RFI, accepted the invitation to a demonstration week. The demonstration involved the vendors employing their respective intermittent test systems to identify intermittent fails generated by the Government Furnished Equipment Intermittent Fault Emulator (IFE). The IFE induces conductive path faults that emulate intermittent LRUs/WRAs faults.

Of the four products evaluated, the Universal Synaptics IFDIS (called the NCompass Voyager) “appeared to be the best product and Universal Synaptics performed, by far, the best during the Industry Week demonstrations.”

It should be noted that the NCompass Voyager is the portable version of the IFDIS that does not include an environmental chamber to stimulate vibration, heat and cold.

5.1.3 Conclusion

Establishes meeting the requirements. This report is another evaluation of IFDIS but against the standard MIL-PRF-32516 and using the Intermittent Fault Emulator. The result of this testing highlights that IFDIS meets the standard.

6.0 Assessment

The following is an assessment of the documents referenced in this report, and how they align with system development practices.

6.1 Need

As stated during Mr. Johns' keynote address at AutoTestCon November 2015, the Department of Defense spends $2 billion annually on No Fault Found issues. These are LRU/WRAs that exhibit problems during employment, but otherwise pass all bench testing regimens. The standard reasoning for this is that these faults are intermittent are environmentally induced. Without the ability to test for thermally or vibrational induced intermittent faults, defective WRA/LRU are put back in to the supply systems.

6.2 Requirement

The MIL-PRF-32516 Performance Specification establishes the standard for an intermittent fault tester. This specification establishes classifications for faults, and references an intermittent fault emulator available to test equipment manufactures. This specification defines the standard that intermittent test platforms must meet in order to satisfy the requirement. This requirement covers the magnitude and duration of the fault as well as the ability to monitor multiple test points at the same time.

6.3 Analysis of Alternatives

IFDIS was the subject of several economic analysis documents comparing the cost of acquiring the solution to the status quo. Various configurations of IFDIS were evaluated to determine the return on investment when including the thermal and vibration environmental chamber. And finally, IFDIS was compared to products from competing vendors.

6.4 Meeting the Requirement

The Universal Synaptics system, NCompass Voyager™, was evaluated against the performance specification MIL-PRF-32516 by the Joint Intermittence Testing Group and they determined that the system "appeared to be the best product and Universal Synaptics performed, by far, the best during the Industry Week demonstrations."[19] In addition, the IFDIS testing of the F-18 GCU performed under the supervision of the US Navy demonstrated the ability of the system to detect issues that current testing procedures missed.

6.5 Conclusion

The Air Force can proceed with implementation decisions related to IFDIS confident that the procurement questions were asked and answered. There is a defined need, requirements

[19] National Center for Manufacturing Sciences, *Joint Intermittence Testing (JIT),* 16

established, analysis of alternatives conducted and positive evaluation that the technology met the requirements.

Appendix A Source Documents

Reference	Document
Brett Gardner, *Navy's First Intermittent Fault Detection & Isolation System (IFDIS)*. Report. Advanced Aircraft Technologies (AAT) FRCSW, 27 October 2015	 201510_Navy IFDIS JTEG for public relea
Ogden Air Logistics Complex Acquisition Cost Division, *G3TL12 F-16 Programmable Signal Processor (PSP) Intermittent Fault Detection and Isolation CIP Economic Analysis,* Report, December 2012	 201212_G3TL12_Hill _AFB_PSP_IFDIS_CIP_
National Center for Manufacturing Sciences, *Joint Intermittence Testing (JIT) Capability – Phase II Final Repor*t. Report. December 2016	 201612_JIT II Final Report.pdf
Troy Bayer, *JIT (Joint Intermittence Tester) Business Case Analysis (BCA) Analysis of Alternatives (AOA)*. Report. 4.2 Cost Analyst. 19 September 2013	 201309_JIT BCA AOA Brief.pdf
Troy Bayer. *JIT (Joint Intermittence Tester) Naval Aviation Enterprise (NAE) Future Readiness Initiative POM17 Return on Investment (ROI) Analysis*. Report. 4.2 Cost Analyst, 4 August 2014	 201408_JIT ROI Analysis.pdf
United States. *MIL-PRF-32516 Performance Specification Electronic Test Equipment, Intermittent Fault Detection and Isolation for Chassis and Backplane Conductive Paths*. By Naval Air Warfare Center Aircraft Division, 23 March 2015	 201503_MIL-PRF-32 516.pdf