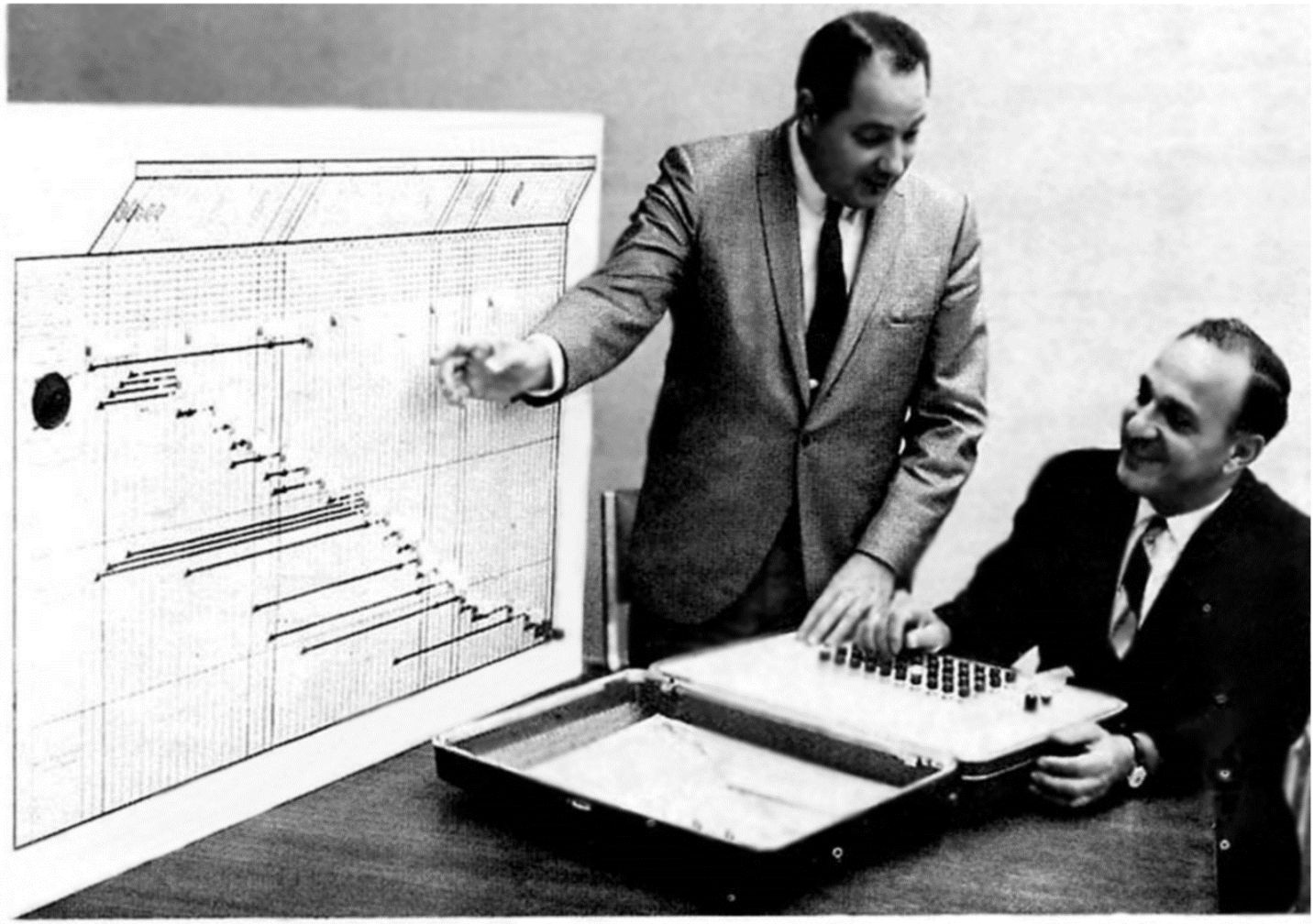
Ever Wonder how or when Testability and DFT Originated?

The Pioneering of Testability and DFT

The History of MIL-HDBK-2165

Many of us prefer to simply learn what's involved in becoming an expert in a technical skill, and then we get on with the task at hand. Congratulations – this is exactly in step with management as well, and for good reason!

Although today, you are going to be briefly introduced to the back-story on how the concept of Testability ever got started. So here we go!



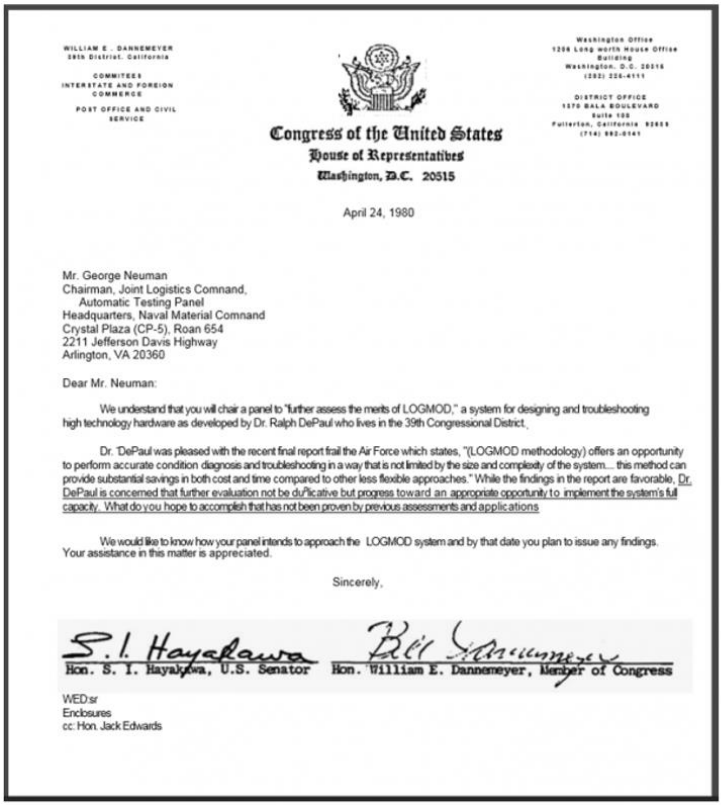
LOGIC MODEL – Ralph De Paul (standing) and Gus Daskalakis display logic model for the XM140 gun, which assists in equipment maintenance. A model also has been constructed for Chaparral weapon system.

April, 1969

We travel back to 1965 when Ralph A. De Paul, Jr. first disclosed a method to represent how any functional or failure dependencies in any domain could be represented by the use of three basic geometric symbols – the circle, square and the triangle. This was conceived and proven by De Paul, long before the Personal Computer was introduced as a term. Even today, you'll notice DSI's tribute to those three symbols in its company branding and logo.

The progression towards Testability, as we know it today, was born!

De Paul would form DETEX Systems, Inc. in 1975, where he began his personal commitment to establishing how the performing of any "Testability Analysis" would be an integral proactive activity for the purposes of influencing the fielded design to be more effective tested and maintained. As one could imagine, he would have many hurdles in the lane that led to his work leading to the publishing of the MIL-STD 2165 "Testability" Standard, as authored by William Keiner – one of De Paul's earlier DoD students of the late 1970's.



WILLIAM E. DANNEMEYER
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Congress of the United States
House of Representatives
Washington, D.C. 20515

April 24, 1980

Mr. George Neuman
Chairman, Joint Logistics Comnand,
Automatic Testing Panel
Headquarters, Naval Material Comnand
Crystal Plaza (CP-5), Roan 654
2211 Jefferson Davis Highway
Arlington, VA 20360

Dear Mr. Neuman:

We understand that you will chair a panel to "further assess the merits of LOGMOD," a system for designing and troubleshooting high technology hardware as developed by Dr. Ralph DePaul who lives in the 39th Congressional District.

Dr. DePaul was pleased with the recent final report frail the Air Force which states, "(LOGMOD methodology) offers an opportunity to perform accurate condition diagnosis and troubleshooting in a way that is not limited by the size and complexity of the system... this method can provide substantial savings in both cost and time compared to other less flexible approaches." While the findings in the report are favorable, Dr. DePaul is concerned that further evaluation not be du"licative but progress toward an appropriate opportunity to implement the system's full capacity. What do you hope to accomplish that has not been proven by previous assessments and applications

We would like to know how your panel intends to approach the LOGMOD system and by that date you plan to issue any findings. Your assistance in this matter is appreciated.

Sincerely,

S. I. Hayakawa
Hon. S. I. Hayakawa, U.S. Senator

Bill Dannemeyer
Hon. William E. Dannemeyer, Member of Congress

WED:sr
Enclosures
cc: Hon. Jack Edwards

JOHN SLATTERY
PROFESSIONAL ACHIEVEMENT AWARD

The late Ralph DePaul, Jr. is the 1994 recipient of the **John Slattery Professional Achievement Award.** It will be presented to a member of his family at the AUTOTESTCON awards luncheon for his contributions to automatic testing in support of the United States national security posture. Mr. DePaul founded DETEX Systems, Inc., known for STAT, a widely used testability analyzer and for opening new pathways for "model based diagnostics.

The award, sponsored by the Automatic Testing Committee of the National Security Industrial Association (NSIA-ATC), honors the memory of John Slattery, a software engineer with the General Dynamics Electronics Division who contributed to the enhancement of automatic test equipment in military and industrial applications. He was active in AUTOTESTCON, the NSIA's Automatic Testing Committee and the Modular Automatic Test Equipment (MATE) Users' Group (MUG) and was Chairman of the group's Subcommittee for Control and Software.

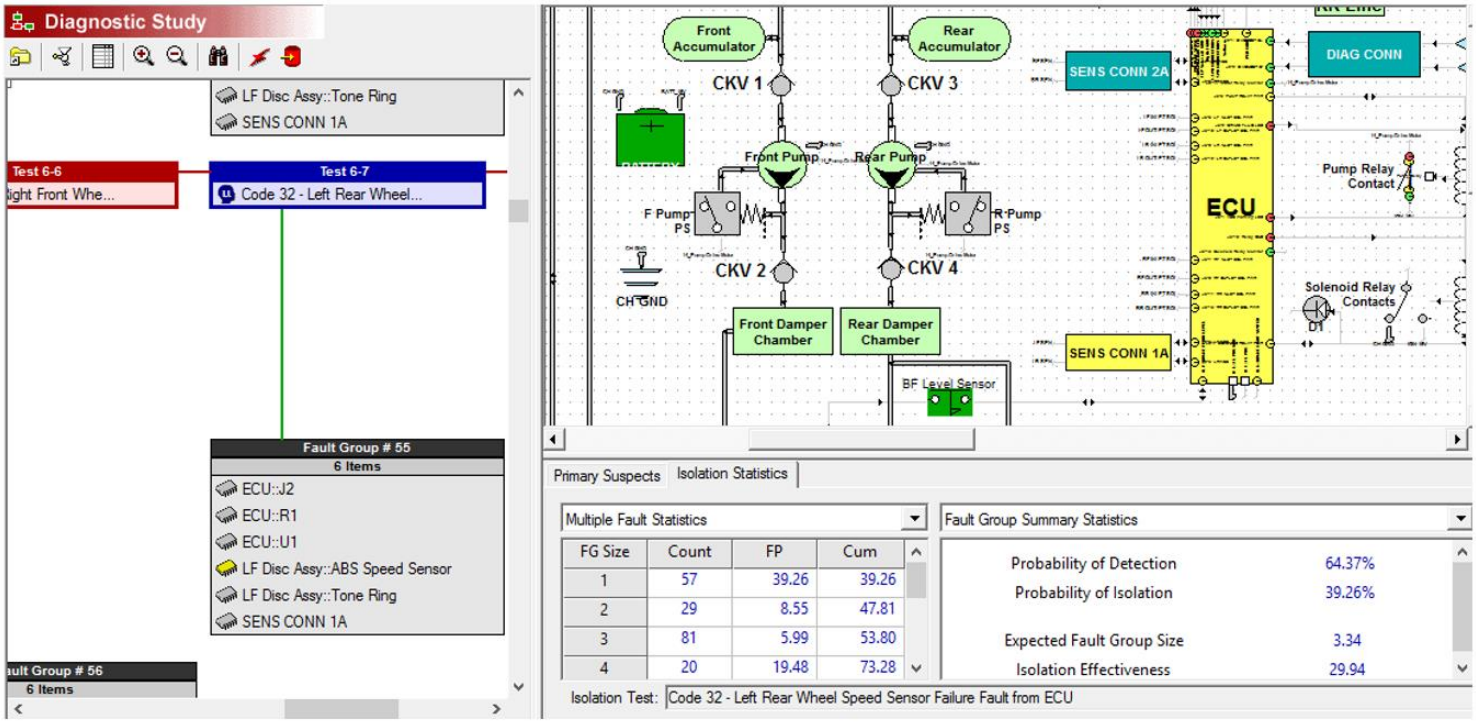
Mr. DePaul was active in the support community from 1956 when he joined Hughes Aircraft Company in Fullerton, CA until his death in 1993. At Hughes, he assisted in the hardware design of nine fi'e control systems and one air weapons control system for the U.S. Air Force, and designed the memory assembly for the MA-1 Flight Control System. He performed all levels of testing on systems he helped design plus the fi'st Frequency Scan Radars used in the Army and Navy, the FALCON Missile System for the Air Force and the TOW Guided Missile System for the Army. It was during this period he began research and concept development of what today is Functional Dependency Modeling. In 1960, he became manager of Hughes' Integrated Logistics and served in that capacity until joining Ford Aerospace five years later as manager of Integrated Logistic Support. There, he continued his work on Function Dependency Model by satisfying maintainability demonstration requirements for a series of weapons systems and developed a forerunner to a portable computerized maintenance aid.

Mr. DePaul formed DETEX Systems in 1975 and was a leading advocate of testability before the U.S. Congress and the NSIA and JPL subcommittees on testing. His persistence led to recognition of a need for a military standard on testability which resulted in ML-STD-2165. At DETEX, he dealt with all types of electronic (analog and digital), mechanical, optic and electro-mechanical hardware.

The timeline at the end of this paper provides hyperlinks to documents that blazed the trail along the way. Yes, De Paul had to work through a local US Congressional Representative to move this along – this was not an easy trail.

Since that time, and with our ears open wide to the sharpest minds in industry, we were able to take this concept of defining the functional and failure interrelationships of *any* design, then organize and formalize the structuring of that data into a comprehensive dependency model. This capability was extended to capture, not just the documented data relevant to form the system models, but also to include design knowledge that often only existing in the minds of the Subject Matter Experts. From here, this knowledge is retained in the model in the form of a *property,* or *asset*, that is extensible in perpetuity.

We refer to these models today as, "***eXpress***" Diagnostic models. The models provide a tremendous advantage for any sustainment activity or to suit any complex maintenance requirements. As the design or the support paradigm evolves, the functional and failure interrelationships are quickly merged into the existing design and new design assessments are immediately reformed as *turnkey* outputs from any design update. From here, and once the Diagnostics are validated in the ***eXpress*** DFI (Desktop Fault Insertion) feature, some of the largest and most complex designs are ready to be fully supported in the operational or run-time environment.



Left: Full System Diagnostic Test sequencing (Down = Good; Right = Bad).
Top Right: Diagnostic Status reflects current position in Isolation sequence (Green = Good; Yellow = Primary Suspects; Teal = Secondary Suspects).
Bottom Right: Testability Statistics (FG = Fault Group; Probability of Detection = Probability of Isolation to one (1) component).

However, the overarching challenge will be to enable the same Model-based structure to actually *integrate* (as opposed to only *incorporate*) the data from all design disciplines and domains, and form an integrated knowledgebase, or *property* that produces interdependent, push-button design assessments, including:

Systems Engineering: Integration with MBSE through SysML-***eXpressML***
Testability or DFT: Fault Detection, Fault Isolation, False Alarms, Test Point Placement
Diagnostics Engineering: BIT and Diagnostic Validation, all basic and all complex or custom assessments
Reliability: FMECA, Fault Tree Analysis, RPN, Sneak Path Analysis, MBSA
Maintainability: MTTI/MTTR, Fault Code Assignment/Management, RCM-PdM-CBM Trade Studies/Simulations
Test & Troubleshooting: Diagnostic Sequencing for ATE, TRDs or TPS

Yet beyond the turnkey design assessments pulled right from the ***eXpress*** models, the second part of this challenge is to add incredible versatility to this same integrated knowledgebase or *property*. To this interrelated purpose, the portion of data required for any implementation, can be dressed up or dressed down to maximize the effectiveness of the integrated ***Diagnostic Reasoner*** in its use in any operational run-time or maintenance role(s), including:

On-board Diagnostic Reasoning: Integration with Health Monitoring or Health Management Systems
Automatic Test Equipment: Integration with Test Executive for Health Monitoring
Guided Troubleshooting: Integration with Portable Maintenance Aids, History and Session Recording databases
Variable Reasoning: Static, Dynamic, Design-based, Empirical
Continued/Integrated Reasoning: Unique Fault Codes integrate Diagnostic Conclusions to all operational paradigms.

Enjoy connecting the dots with the timeline and be sure to challenge your audience on how all of this came into fruition and to how it led to where it evolved today!

MIL-HDBK-2165 History

A detailed chronology of the history of DETEX Systems, Inc., its founder, Ralph A. De Paul, Jr., in its intrinsic role in the maturation of Testability, MIL-STD 2165, Design for Test, Integrated Diagnostics, MBSE and Designing for Sustainment.

- **04/1965**: De Paul prepared a Design Disclosure Format (DDF) document that was incorporated into MIL-M-24100(A);
- **06/1966:** MIL-M-24100(A) Published;
- **09/1967:** DDF was enhanced by De Paul to include Fault Isolation and "Performance Monitoring" with Semi-Automated techniques. "FIST" documented to refer to "Fault Isolation and System Test" - still a precursor to ML-STD 2165;
- **01/1974:** Release of MIL-M-24100B, co-authored by De Paul. This is the final precursor to MIL-STD-2165. The DDF was the first document to formalize the use of failure, function, test dependency model, known as Maintenance Dependency Charts (MDCs);
- **02/1975:** De Paul forms DETEX Systems, Inc. and formalizes the first computerized use of the MDC in field applications in all branches of DoD. This formalization was identified as an innovation to use this test and isolation representation for Maintenance activities as the Logic Model, or "LOGMOD";
- **05/1977:** LOGMOD hosted on Portable Computerized Device for Maintenance was first introduced to the US Army at Moffett Field. US Army concludes that *"The logic modeling concept is considered to be an engineering innovation;*
- **10/1978:** USAF concludes that LOGMOD is an effective tool for Guided Troubleshooting;
- **04/1980:** Letter from Congressional Leaders to US Joint Logistics Command (JLC) stating that *LOGMOD offers accuracy to diagnosis and troubleshooting* that is not limited to size or complexity and could provide substantial savings in cost;
- **08/1980:** Lockheed (Burbank) purchases Source Code (Internal Use) License of LOGMOD from DETEX Systems, Inc. for $375,000.00 to target F-117. Part of the Agreement prohibited DETEX to sell Source Code License in Industry for a limited time;
- **12/1980:** LOGMOD used as a "Testability Tool", declared by Joint Logistics Command (JLC) Panel on Automated Testing (William L. Keiner);
- **05/1981:** DETEX Systems, Inc. supplies US Army with first prototype versions of a (battery-operated, electronic, hand-held) *Stand Alone Maintenance Aid,* or "SAMA" for Guided Troubleshooting;
- **01/1985:** MIL-STD-2165, the first recognized testability standard released. William Keiner (US Navy) was the author of MIL-STD-2165, who authored MIL-STD-2165 after frequent visits to De Paul of DSI International over a 5-year period *(see letter to JLC;*
- **11/1986:** DETEX Systems, Inc. selected to team with Lockheed (Georgia) to co-author MIL-STD 1814, "Generic Integrated Maintenance Diagnostics (GIMADS)";
- **10/1988:** DETEX Systems, Inc. delivers *first Licensed Desktop PC* copy of STAT (System Testability Analysis Tool) to Boeing;
- **03/1989:** DETEX Systems, Inc. contracted to co-develop US Navy's Weapon System Testability Analyzer (WSTA);
- **09/1994:** Ralph De Paul awarded IEEE John Slattery Award for using Testability opening pathways to "Model-Based Diagnostics;
- **05/1996:** DSI International, Inc. resumes for DETEX Systems, Inc. after passing of Ralph A. De Paul, Jr.;
- **02/1997:** DoD releases MIL-STD 1814 and the companion AF Guide Specification, identifying LOGMOD and DETEX Systems, Inc.;
- **08/1998:** DSI releases ***eXpress*** – the first Model-based based diagnostics targeting the PC that produces diagnostic assessment and test sequencing for ATE and guided troubleshooting using a proprietary functional and failure "hybrid" methodology;
- **09/2003:** Navy recognizes DSI for steering the IEEE Standard 1232-2002 newest Testability Standard (published in 2004);
- **04/2014:** MIL-STD-2165A reclassified as a handbook, MIL-HDBK-2165.