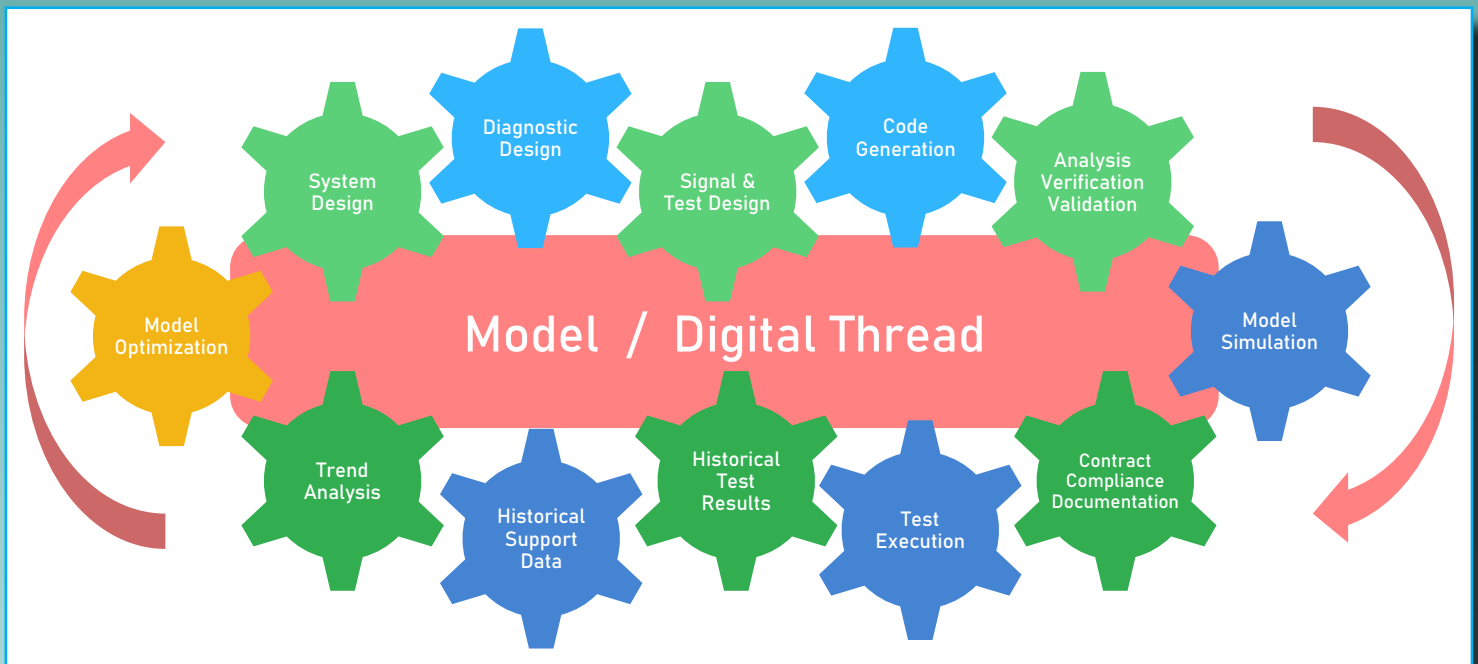


Closed-Loop Digital Thread for MBDE

The digital integration of test and diagnostic engineering practices is not a new idea. In 1989, DSI International and the TYX Corporation demonstrated what we would today call a “digital thread” in which data from design databases was imported into STAT (DSI’s diagnostic engineering tool at that time) and used to generate diagnostic test sequences which were then transferred to TYX’s Professional ATLAS Workstation (PAWS) to create test requirement documents and test program sets—a process that was described back then as “From CAE to ATE”.

Early attempts at digital integration relied mostly on proprietary interfaces between tools. Widespread adoption, however, would not occur until data could be interchanged using standardized formats. In 2015, Reston Software and Sphera Technology spearheaded the unprecedented “ATML-enabled, Standards-Powered, COTS-Based Solution” to diagnostic development and deployment. In this process, test sequences generated in **eXpress** were converted into test programs for TestStand and LabVIEW, with additional guided troubleshooting provided by DSI Workbench—all based on a single digital thread. Significantly, this integration was achieved entirely using COTS tools and open formats (such as ATML and DiagML).



The introduction of the eXpressML format in 2018 (and its subsequent translation from SysML) ushered in a new age of MBDE (Model Based *Diagnostic* Engineering). Then, in 2021—with the incorporation of trend analysis from historical test results—the loop was finally closed. A team of four companies demonstrated a cyclical diagnostic engineering process based on a composite digital thread. This process—again based entirely on open formats—is outlined in this brochure.

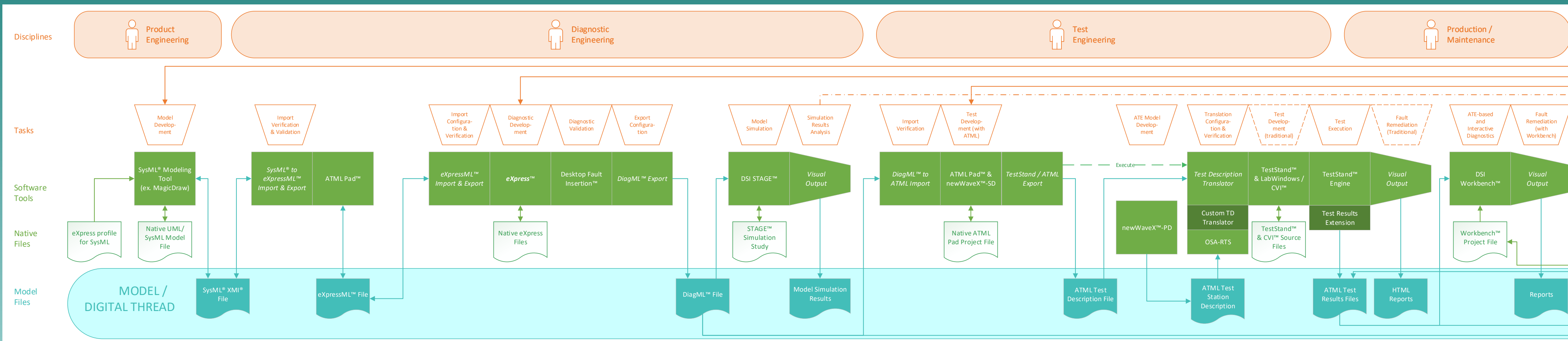
The table at right lists all the open and standard-based formats used by this process. The various IEEE formats were first used (along with DiagML) in the 2015 solution described above.

The SysML XMI & eXpressML formats were added to this process in 2021, effectively transforming this diagnostic development paradigm into full-on Model Based Diagnostic Engineering.

Format / Standard ¹	First Published	Description
SysML [®] XMI [®]	tool specific	Systems Modeling Language XMI
eXpressML [™]	2018	eXpress Diagnostic Model Markup Language
DiagML [™]	2001	Diagnostic Markup Language
IEEE 1641	2004	Signal and Test Definition
IEEE 1671.1	2009	ATML ² Test Description
IEEE 1671.2	2008	ATML Instrument Description
IEEE 1671.6	2008	ATML Test Station Description
IEEE 1636.1	2007	Test Results and Session Information

¹SysML and XMI are registered trademarks of the Object Management Group[®]
eXpressML and DiagML are trademarks of DSI International, Inc.

²ATML is the “Automatic Test Markup Language” family of IEEE standards



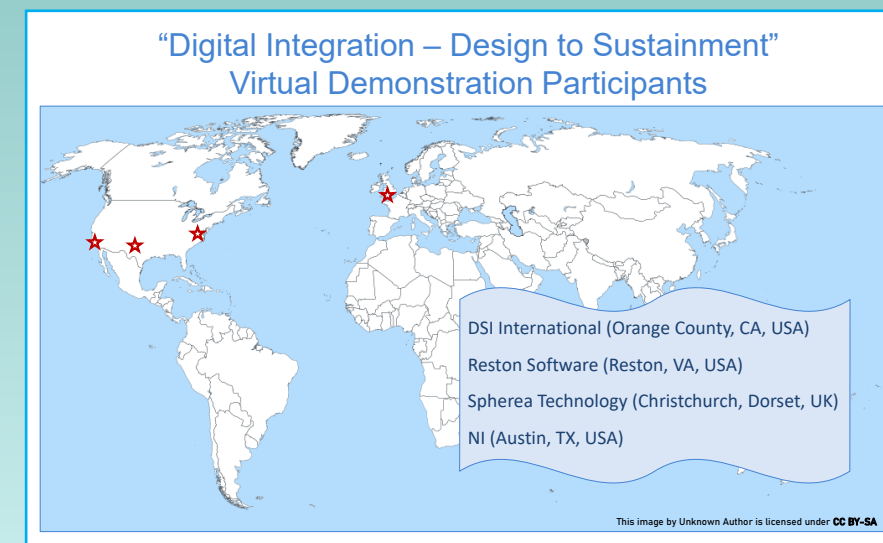
The industry-leading tools depicted in the diagram above are widely recognized in the design, test and diagnostic communities. However, because integration is achieved using data stored in published standards and formats, other tools that support these formats can be added or substituted within this process. Moreover, this is only an indicative example; different projects may result in alternative process flows that utilize these same tools and formats. In fact, most of these tools have a number of useful features that are not being represented in this sample process.

The following chart lists these tools, along with the formats utilized in the process depicted above:

Tool ¹	Provider	Formats / Standards ⁵
CATIA MagicDraw®	Dassault Systèmes ³	SysML XMI
ATML Pad™	Reston Software, LLC	SysML XMI, eXpressML, IEEE 1671.1, IEEE 1641
eXpress™	DSI International, Inc.	eXpressML, DiagML
STAGE™	DSI International, Inc.	DiagML
newWaveX™	Sphera Technology, Ltd.	IEEE 1641, IEEE 1671.2, IEEE 1671.6
OSA Runtime System (OSA-RTS) ²	UK Ministry of Defence	IEEE 1671, IEEE 1641
NI TestStand® & LabWindows™/CVI	NI (National Instruments) ⁴	IEEE 1671.1, IEEE 1636.1
Run-Time Authoring Tool (RTAT™)	DSI International, Inc.	DiagML, IEEE 1636.1
DSI Workbench™	DSI International, Inc.	IEEE 1636.1
Diagnostic Aid	Sphera Technology, Ltd.	IEEE 1636.1

¹The software listed in this brochure are all trademarks of their respective providers. Please contact these companies for additional information about their tools.
²OSA-RTS is Crown Copyright © 2014. This software has been made available as "open source" to facilitate use of the ATML standard within Runtime systems.
³Although CATIA MagicDraw was used to produce the SysML XMI in this process, Dassault Systèmes was not a participant in the multi-tool demonstration.
⁴There are ongoing efforts to translate SysML generated by other MBSE tools (e.g., Capella™) and to support project-specific SysML extensions and stereotypes.
⁵The other companies and software programs referenced within this brochure are not affiliated with, endorsed by, or sponsored by NI (National Instruments).
⁶The formats described in this brochure are limited to those used within this demonstration. Please contact tool providers for a list of all supported formats.

The entire process described in this brochure has been demonstrated virtually under the title "Digital Integration – Design to Sustainment". In this demo, representatives of four different tool vendors (each located in a different city) integrated their respective test and diagnostic engineering efforts by passing data back and forth over the internet using the formats listed above. Videos of the 06-23-2021 demo are available from DSI International.



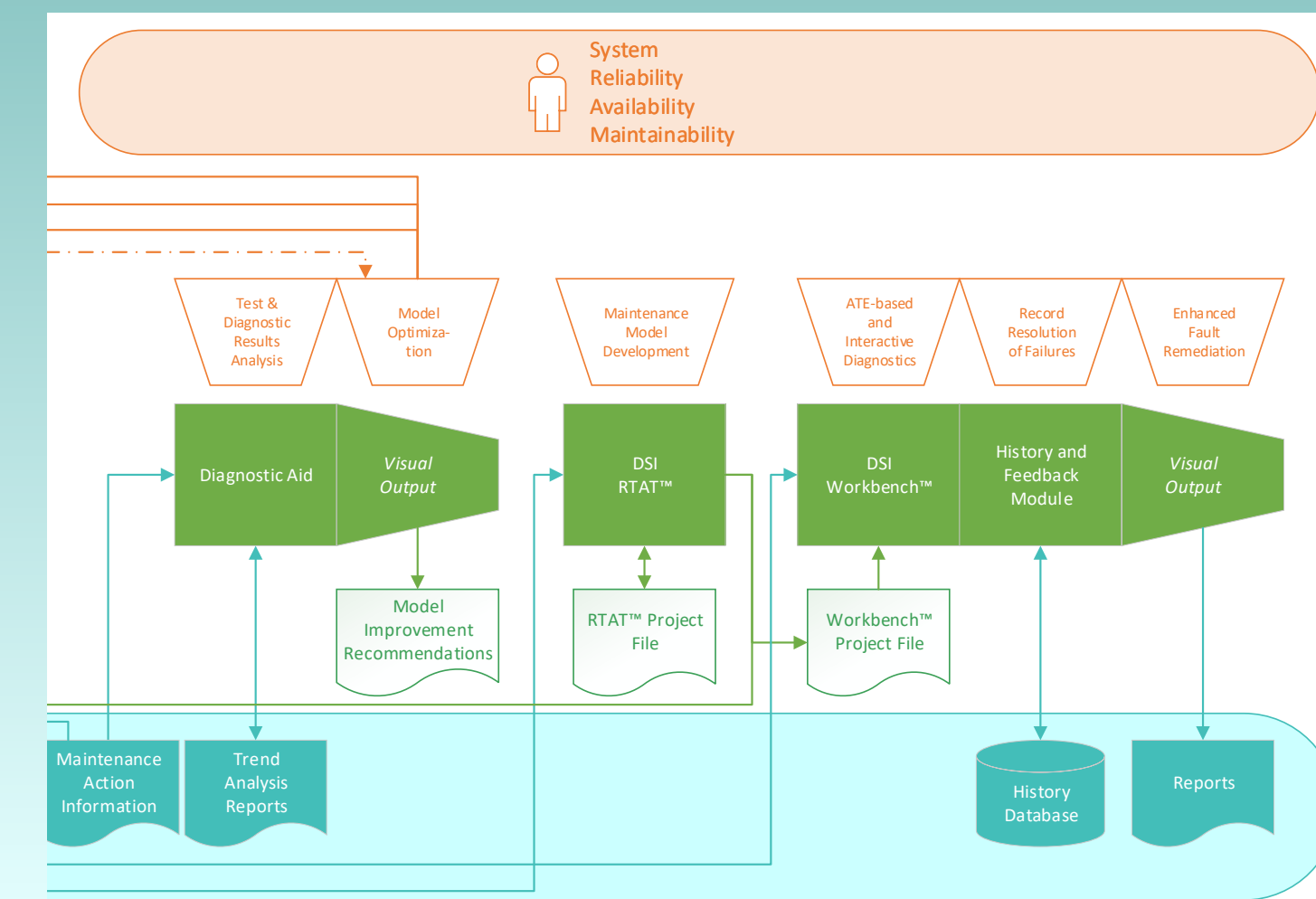
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Diagnostic Aid analyzes historical test results (IEEE 1636.1), allowing the actual reliability and availability of a system to be compared with contracted and predicted performance. This knowledge can then be used to improve the design or update diagnostics/testing to better meet system goals.

The History & Feedback Module of DSI Workbench records historical diagnostic and maintenance data in a database to be used as an empirical extension of the engineering-based diagnostics developed in **eXpress**.

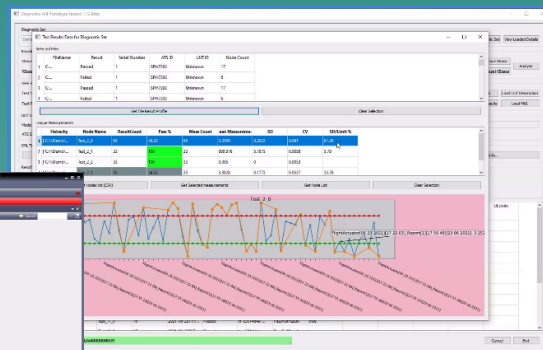
The Run Time Authoring Tool (RTAT) uses DiagML data from **eXpress** to develop IETM (i.e., troubleshooting) projects for DSI Workbench

DSI Workbench reads in the generated IEEE 1636.1 test results and displays instructions to the maintainer using its image-based GUI.

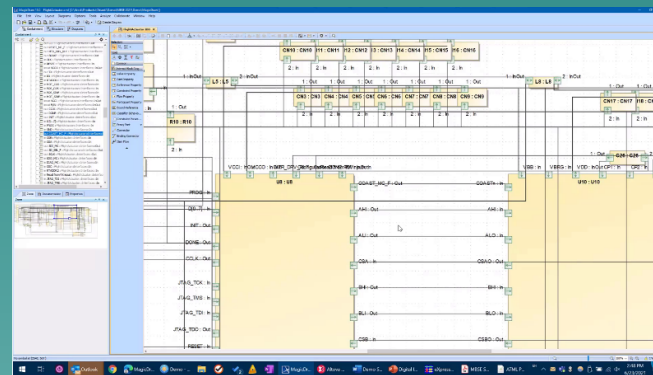
LabWindows / CVI

The NI TestStand ATML Toolkit and newWaveX-PD, integrated within the OSA-RTS framework, are used to generate complete test programs for TestStand & LabWindows/CVI.

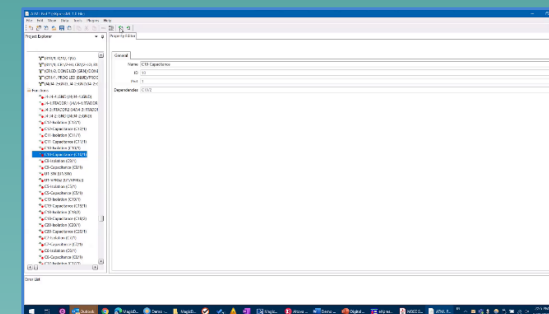
NI TestStand & LabWindows/CVI run the test programs, storing the test results in IEEE 1636.1 format.



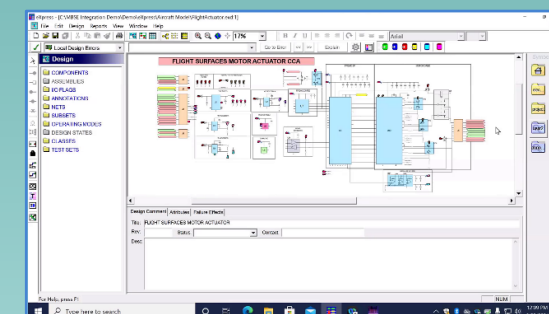
Diagnostic Aid



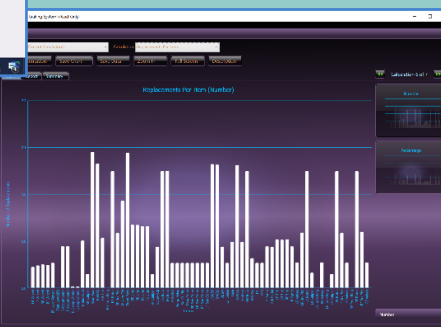
MagicDraw



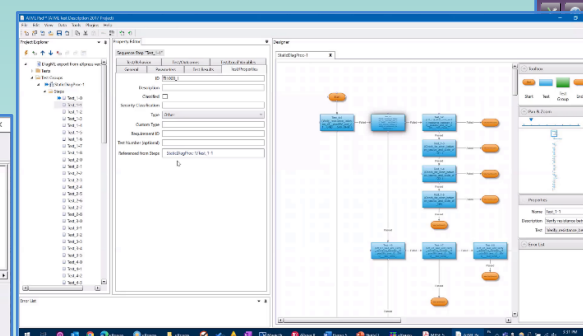
ATML Pad / eXpressML



eXpress

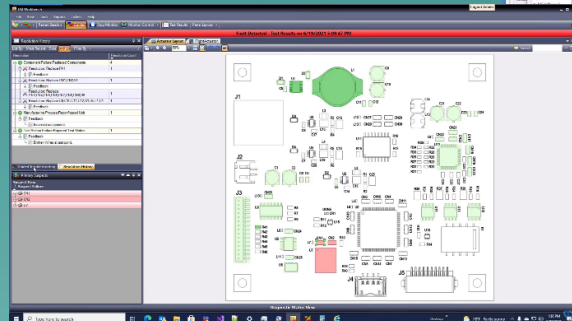


STAGE

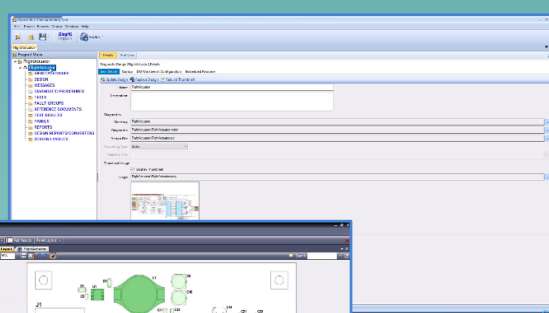


ATML Pad / ATML

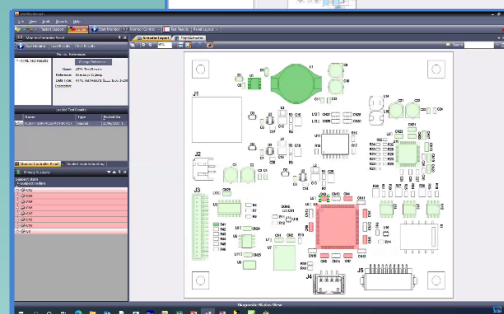
ATML Pad and newWaveX-SD are used to develop signal and test descriptions, which are stored as IEEE 1641 TSF Libraries and in the IEEE 1671.1 ATML Test Description document (with embedded signal descriptions encoded as IEEE 1641 XML).



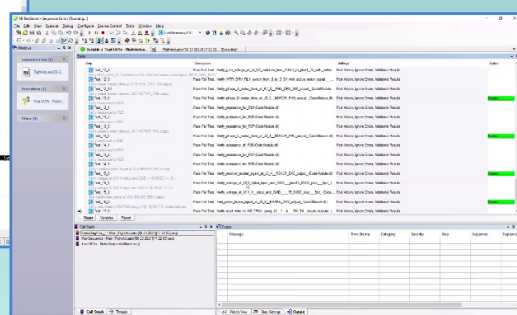
Workbench (History & Feedback)



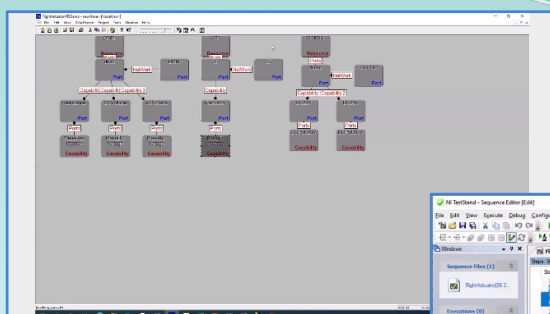
RTAT



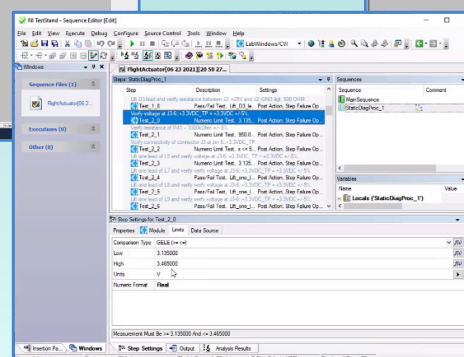
DSI Workbench



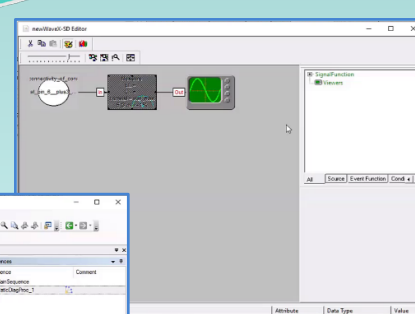
NI TestStand



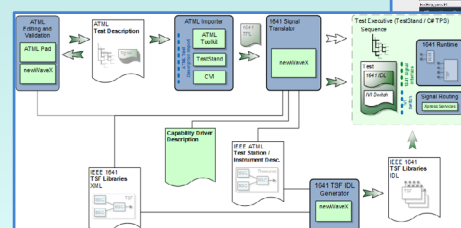
newWaveX-PD



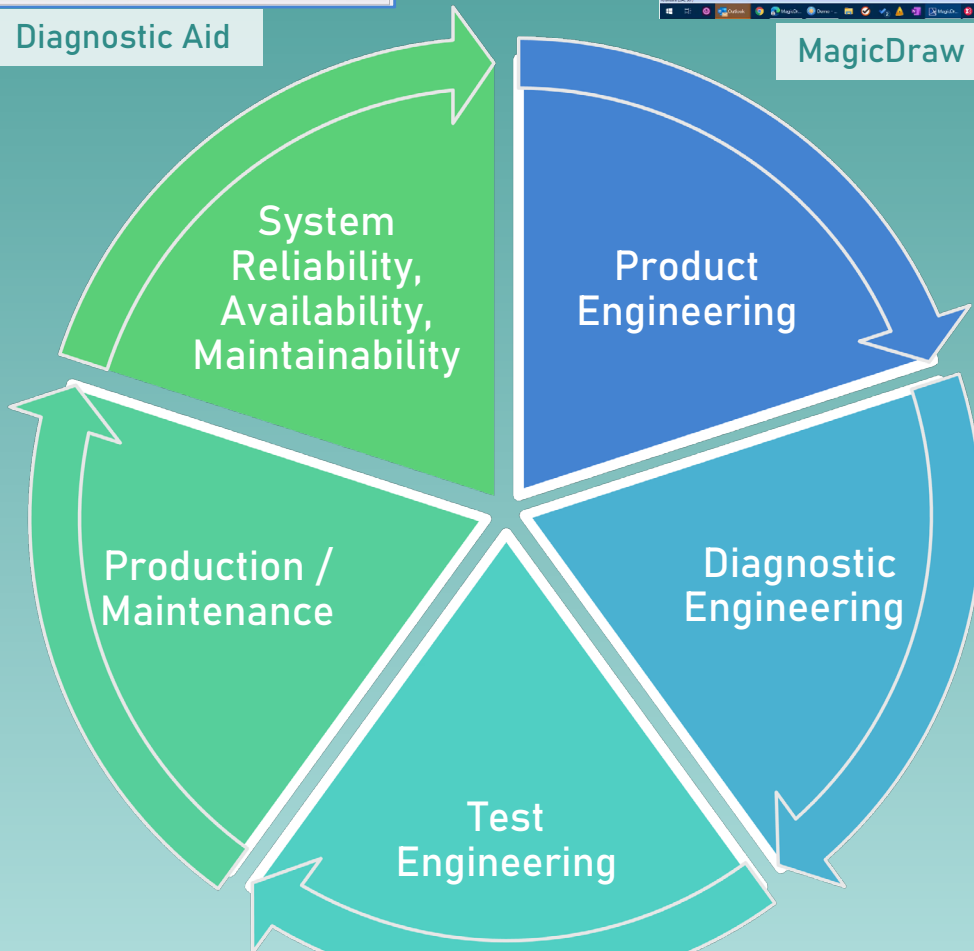
NI TestStand / ATML Toolkit



newWaveX-SD



OSA-RTS



The SysML database represents the authoritative source of truth for most Model Based System Engineering (MBSE) implementations.

MBSE design data from MagicDraw is brought into **eXpress** (facilitated by ATML Pad translating the SysML XML data to eXpressML).

The eXpressML format allows design topology, reliability predictions and project-specific data to be imported into **eXpress**, where it is used to develop test sequences, validate them using Desktop Fault Insertion™ and perform diagnostics-informed assessments of the design.

Diagnostic test sequences developed in **eXpress** are exported as DiagML.

This is used by STAGE to derive simulation-based maintenance predictions that take into account diagnostic performance.

ATML Pad translates the DiagML into the ATML Test Description format (IEEE 1671.1), thereby creating the test model used for signal and test development.