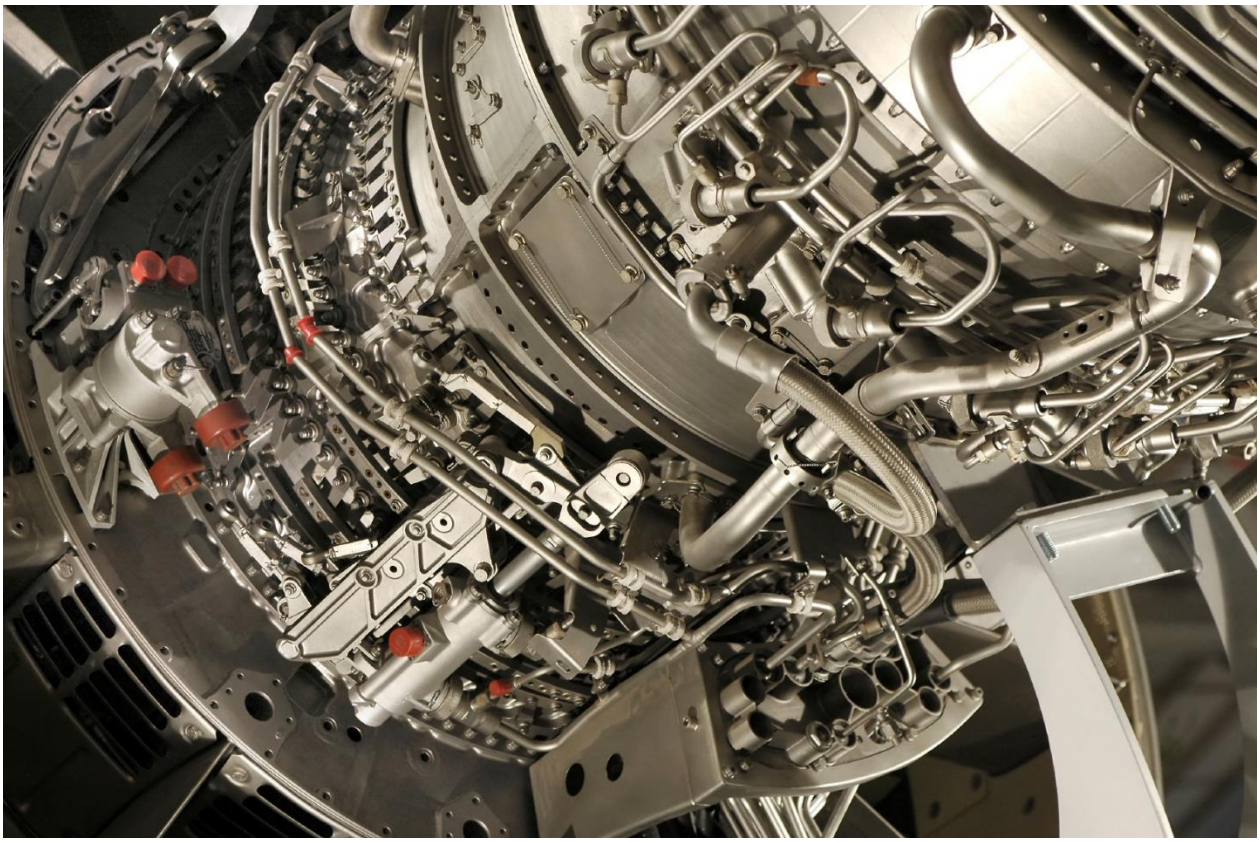
“Test Result *Correlation*” versus “Diagnostic *Reasoning*”

Integrating advanced on-board Health Management systems with off-board Diagnostic Solutions



Q: Doesn’t industry already have on-board “Diagnostic Reasoning” for complex assets?

A: Actually, not really, and there is a significant difference…

As system functional status checks are performed by the on-board BIT that may use a variety of advanced sensing technologies, the data received from the sensors enable the determining of the system’s *health status*. The data used to determine the health status of the system is reported in terms of whether or not the executed functional BIT test either “passes” or “fails”.

As multiple sensors are used to report health status of any number of functions on a continuous basis, the collection of the aggregate reporting of the on-board BIT is able to establish a *Fault Signature*. The Fault Signature is typically “correlated” against any pre-defined set(s) of possible “passed” or “failed” BIT that have previously been determined to represent any failure(s) that may exist, or likely to manifest into a failure within the system.

On complex systems, this "BIT Status" reporting is imperative as it provides data to the Health Management ("HM") systems for executing near instantaneous operational mitigating or corrective actions.

While this is typical and essential for most on-board HM applications, the corrective or mitigating actions must error on the side of being "aggressively conservative". For example, a corrective action may be to switch to redundant path or degraded mode when a BIT Fault Signature "correlates to" any pre-defined BIT Failure Code Signatures – or any derivative "seemingly" thereof.

In the experiencing of such critical events, there is no value in expending any time to compute any root cause of the failure(s). Instead, most every mitigating corrective action for HM systems will appropriately prioritize safety, and the asset will immediately pursue that objective. Diagnostic ambiguity is acceptable when traded against the pursuit of time-critical safety – even if an operation or mission was aborted falsely!

However, once the urgency has been mitigated, the asset will need to be "diagnosed" before being placed back into service. Here is where the "***Diagnostic Reasoning***" is King.

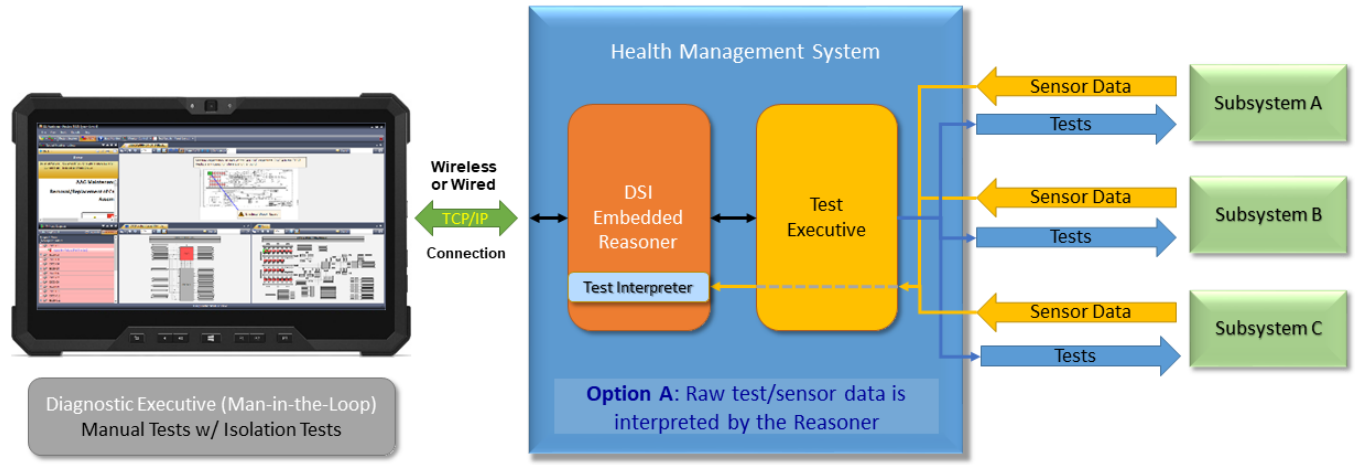
Traditional Health Management Systems: Strong on-board – Weak in seeding off-board Diagnostics

Unfortunately, on-board HM systems do not typically provide as much insight to off-board diagnostics despite what most everyone gives them credit for. In fact, they are quite stingy. All that the on-board HM system is typically able to provide is simple entry point into the "off-board" or next "diagnostic level" using the BIT "Test Results". That is all that is carried to the diagnostic environment. Unfortunately, traditional on-board HM system designs essentially ***dismiss*** the opportunity to provide sufficient Diagnostic detail that could largely benefit the purposes of a cost effective sustainment paradigm. This is sinful for anyone aspiring to be a "Whole-Life" or "Life Cycle" Systems engineering juggernaut.

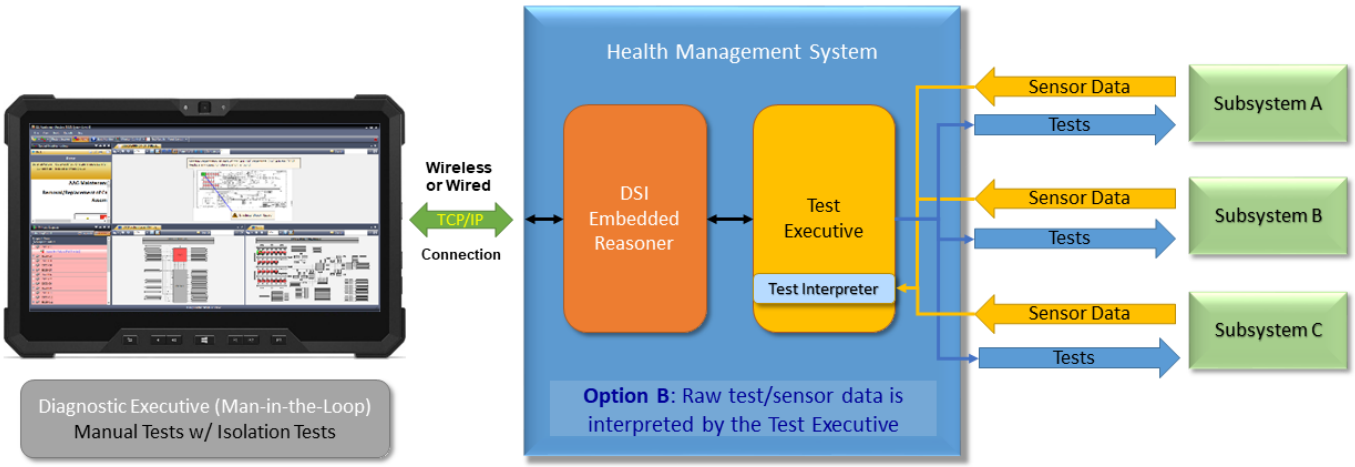
On-board HM Systems target very specific purposes. In fact, the traditional requirements for the on-board HM is blissfully unaware of the tremendous advantage that could be gained from becoming more concerned about gathering the "bridging" of the on-board "Test Result Correlation" to the off-board Diagnostic application. It is rather simple, and a sustainment "cash cow", when the customer or asset owner is *in-the-know*.

How does the ***eXpress*** Embedded Reasoning differ?

The ***eXpress*** Embedded Reasoner is not intended to serve as an immediate, risk-mitigating capability as is the on-board HM systems described above. Instead, the ***eXpress*** Embedded Reasoning is able to function contemporaneously with this on-board HM, if any. If not, the Embedded Reasoner is still able to uniquely gather extensive diagnostic detail from the on-board BIT status, enabling it to form and transfer "diagnostic conclusions" to the off-board diagnostic environment or Automatic Test Solution (ATS).



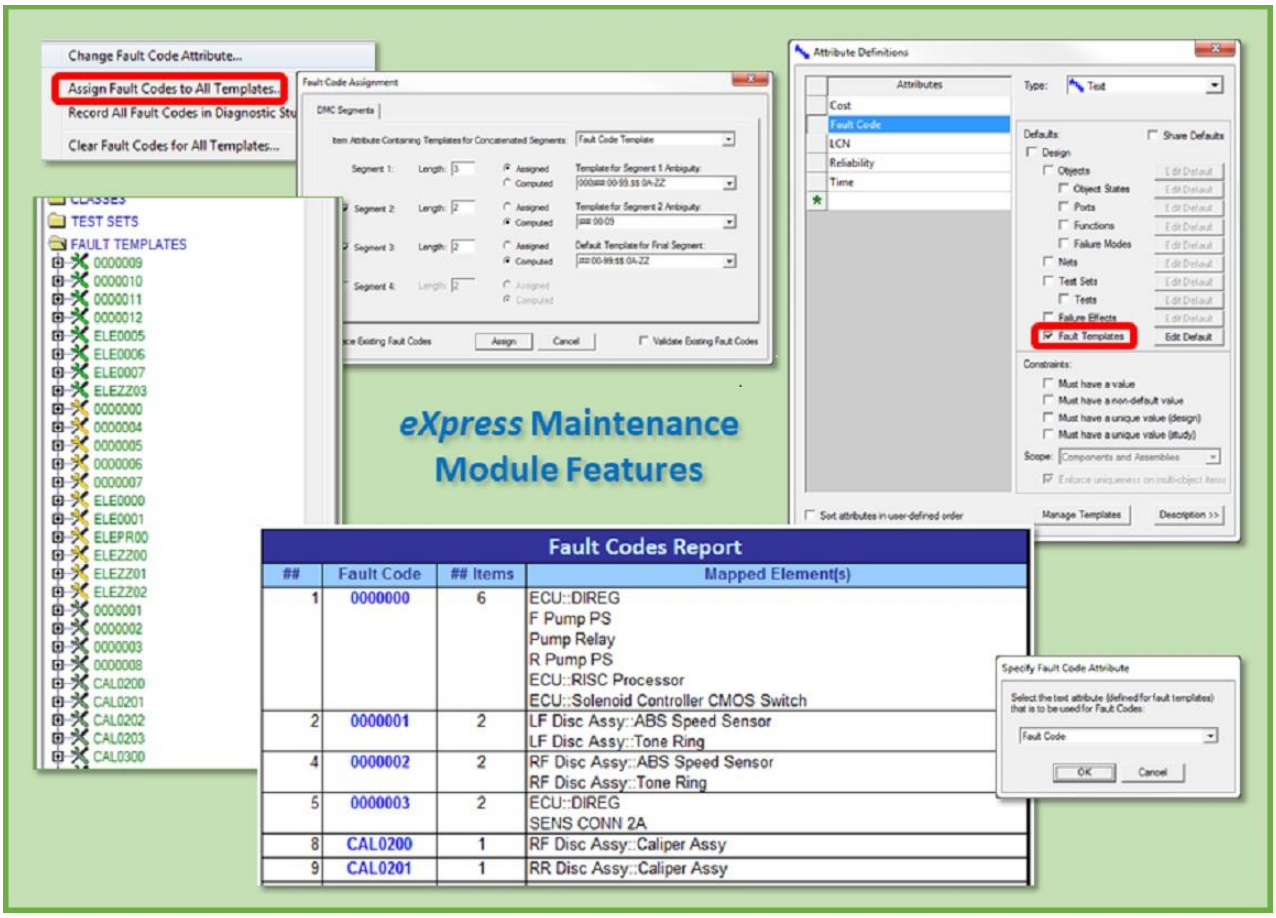
Configuration 1 of 2



Other Options and Configurations are Available and can be Customized to Each Customer's Needs

Encapsulation of "Diagnostic Conclusions" within Fault Codes

These diagnostic conclusions are ***encapsulated within the Fault Codes*** that have been pre-defined within the advanced ***eXpress*** diagnostic engineering activity. As a result, the Fault Codes will contain extensive diagnostic inferencing capabilities that are not otherwise possible. As the design is modified or is changed over the sustainment lifecycle, this technology within ***eXpress*** allows for the immediate reconfiguring of the Fault Codes to contain any modified diagnostic detail with minimal human interactivity and virtually no opportunity for error.

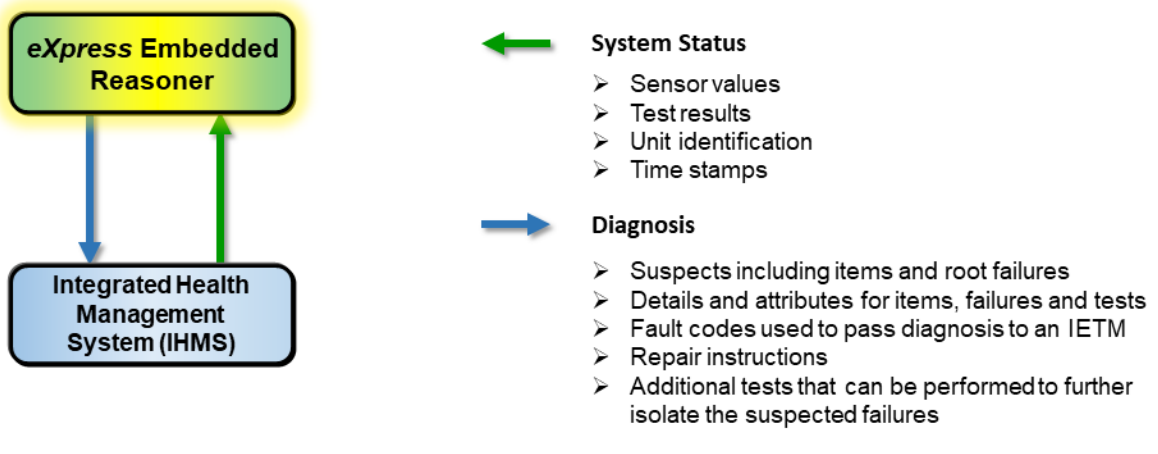


Enriching, Embedding and Mobilizing the Diagnostic Knowledge

Since the diagnostic knowledge is contained on-board within the ***eXpress*** Embedded Reasoner, the diagnostic detail can offer enhanced utility if ***eXpress*** is used to influence the design during design development.

However, any possible diagnostic detail that can be extracted from any existing legacy design can also be fully contained within the ***eXpress*** diagnostic engineering paradigm. In such case, limitations to gaining full diagnostic detail is determined by the inherent diagnostic capability of the legacy design.

Still, the on-board BIT can gain vast new diagnostic inferencing from system and health status interrogation. However, this is NOT a capability of any asset deployed where the diagnostic design has not been previously captured by ***eXpress***.



Messaging between the embedded reasoner and the IHMS

How do we realize the maximum potential of the off-board effectiveness gained from our existing HM or while using the *eXpress* Embedded Reasoner?

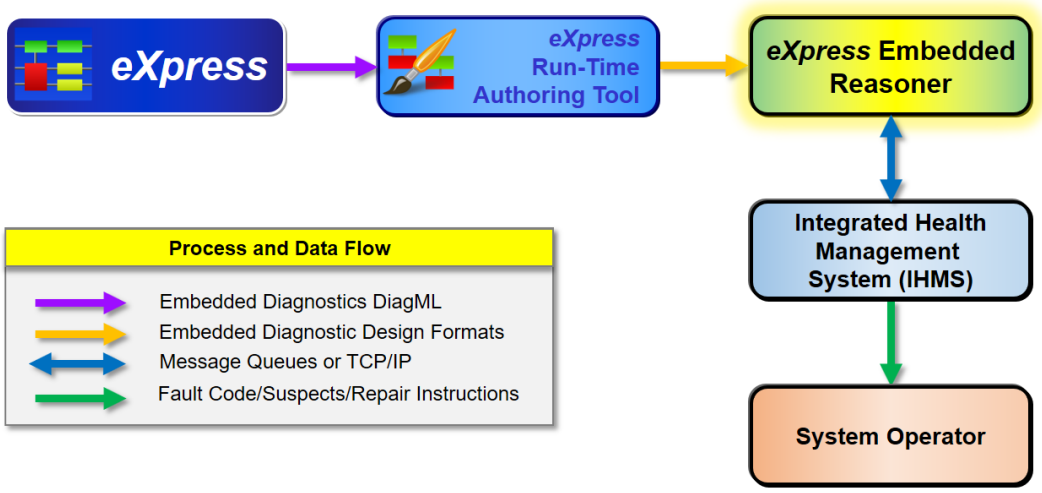
From this second-level diagnostic entry point, all available diagnostic detail gained from the on-board HM system is transferred to the off-board (secondary level) diagnostic paradigm. If a particular IETM or Portable Maintenance Aid is required, then the diagnostic capability can be transferred to that environment.

For a most diagnostically-effective experience that can be used equally by most any skill level technician, DSI Workbench is able to be hosted on any approved portable and capable device to realize the maximum "potential" off-board diagnostic effectiveness.

Diagnostic Conclusions are fully transferable

- Choose the environment or constraints – whether it shall be the field, shop, ship, depot, production lab, on vehicle console.

- Transfer the diagnostic knowledge – for use to any sustainment paradigm or solution. Although the images (below, etc.) depict the use of the full DSI Workbench capability in a generic Portable Maintenance application, the diagnostic acumen can be integrated with most any simple or high-end Test Solution.



eXpress Embedded Reasoner Development & Data Flow

- Choose your device - whether it be DSI Workbench directly, embedded within or via an API with:
  - High-end or specialized ATE for any highly capable solution(s) including NGATS, OPATS or any Joint ATS solution that may need to be compatible with ATML, S1000-D data formats or specific to any unique implementation.

DSI Workbench PEMA - Laptop

DSI Workbench PEMA - Tablet

- Reduce or Eliminate CND's, NFF's, RTOK's – typical symptoms of weak diagnostic engineering. One of the most avoidable contributors to the runaway sustainment costs compelling the living with evolving "Can Not Duplicates", "No Fault Found", or "Re-Test OK's". These largely occur due to the loss of diagnostic certainty between the operational system and the maintenance activity.

- Track or record resolution history – view images or videos of test or repair solutions, that focus right to the lowest repairable/replaceable item(s) or root cause every time. Never misdiagnose again!

Further Details:

eXpress Newsletter, Fall 2017
Video: Live Demonstration

Craig F. DePaul