eXpress™ Newsletter

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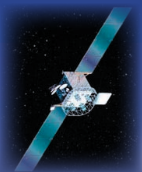







From Diagnostics to Prognostics with eXpress

Good Diagnostics as a Baseline - There's a general consensus that has finally been reached (one that DSI has long supported), which is that good prognostics requires good diagnostics. That is, a good diagnostic approach is essential before trying to migrate to prognostics. While this may not sound like a big deal, failure to recognize that prognostics needs diagnostics can result in the failure to either.

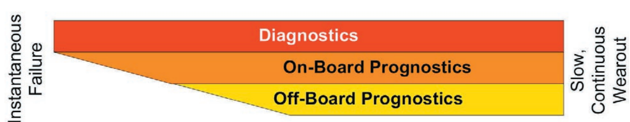
Of course, "talking the talk" and "walking the walk" are entirely different and one is left with the question of how to accomplish the transition. How does one begin with a good diagnostic approach and add prognostics without disturbing the diagnostic foundation? Our solution will focus on ***eXpress***, specifically on two key features--its hybrid model and its test capability.

First, it is worth reiterating how good diagnostics are achieved. As is true of nearly all System Engineering processes, the process of developing a diagnostic solution is iterative. ***eXpress*** uses tests to capture diagnostic knowledge as part of the iterative process. With each iteration, the design is modified (more test points, new tests, etc) and the tests provide the mechanism by which those design changes can be assessed. Ultimately, and with proper tooling in the hands of skilled engineers, the diagnostics of the system can be improved to meet requirements (e.g. 98% detection, 95% isolation to 1 LRU).

What also happens throughout design capture, as well as test definition to a certain degree, is the addition of functions and failure modes. ***eXpress***' ability to support both types of failure modes simultaneously through its hybrid diagnostic model, provides the engineer with a powerful testing capability. Since functions and/or failure modes can be tested, the engineer can decide which approach best captures the diagnostic knowledge. Functional testing tends to be used the higher in the system one tests, or the earlier in the design process one is capturing diagnostic knowledge (that is, before failure modes are known).

Trade-offs for Diagnostics & Prognostics - The realm that exists between diagnostics and prognostics is often ignored or marginalized. In practice, however, diagnostics and prognostics are not as well separated as one might think. Few failures, for instance, occur instantaneously throughout the system. In such cases, detecting the failure at its source and then reacting in time before it propagates can be seen as prognostics from a systems point of view—the failure was avoided before it occurred at the system level. While many might argue that it is still diagnostics because a failure did, in fact, occur, one must consider the fact that prognosing normal wear and tear is actually the diagnosing of failure at the material or sub-component level. Another case is intentionally exceeding the rating on components. One can attempt to prognose the amount of damage that is present, or one can simply account for the amount of time the component has been stressed. While each has merits, one must trade-off the cost versus accuracy gained by utilizing a more advanced technique.

The following figure identifies the realms in which diagnostics and prognostics can be applied.



This figure draws attention to the fact that only diagnostics is meant to react to existing failure, while any of the methods shown can address slower, predictable wear-out. What often dictates the selection of a particular technique is the ease to which it can be implemented, as well as the cost to do so. Maintenance and safety must always be considered as the reasons why a solution is chosen. Often these means trading a diagnostic approach that incorporates redundancy against a prognostic approach that avoids the redundancy. In fact, that exact example is one that was encountered by the Joint Strike Fighter (JSF) program, in regards to selecting a single- or dual-engine approach.

During the maturation of the diagnostics, tests are best created within the ***eXpress*** environment in sets that represents types of testing. In this way, a test set will typically contain a group of similar tests like Initiated BIT. This grouping of tests is what enables simple diagnostic trade studies.

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Incorporating Prognostics into the diagnostic approach requires understanding of a few basic principles:

- Prognostics ***can't*** increase Detection Coverage
- Prognostics ***can*** reduce ambiguity
- Prognostics ***can*** detect failures before they occur
- Prognostic Tests ***can*** detect failure before Diagnostic Tests

Therefore, we can conclude that as we add Prognostics, our detection percentage should remain the same. What we will hope for is detection before a critical failure, or fault isolation to a smaller fault group

Accounting for Prognostics Trend Analysis and Prediction - Trend analysis and prediction represents a processing capability that is added to the system. Most often, it runs on-board and supplies enough information to remediate before a critical failure. It can also be used for condition-based maintenance (CBM) and a host of other situations where detection prior to actual failure provides cost and safety benefits.

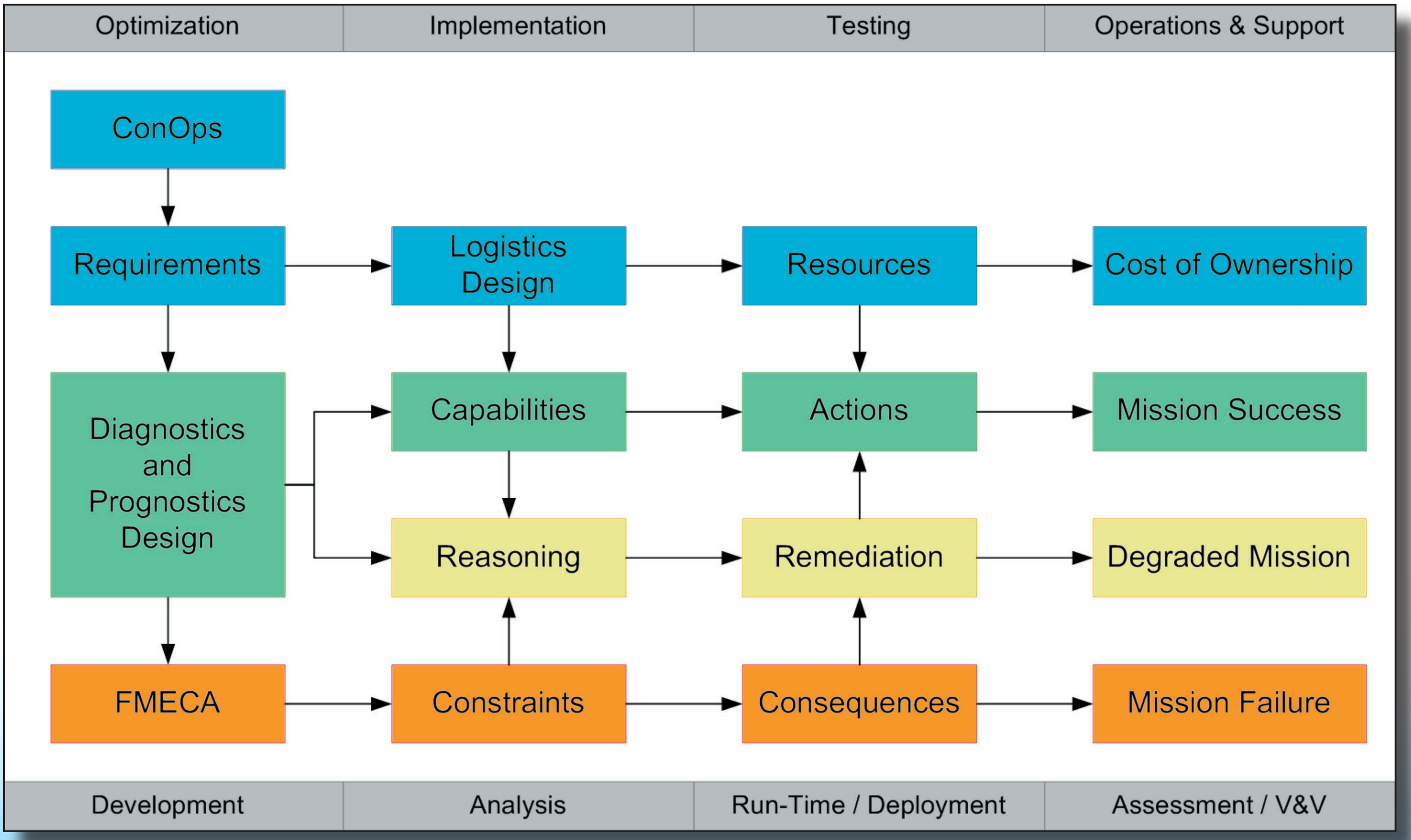
Accounting for this capability in the design itself is done by acknowledging the percentage of time that failures can be detected prior to their failure. That is, to what degree can insipient failures be recognized.

In ***eXpress***, there are two approaches to adding this knowledge. First, let's consider the case where only functions exist, and there are no failure modes on the component of interest. In this case, ***eXpress'*** hybrid diagnostic model provides a quick and simple solution. Add a failure mode for each prognostic capability with a rate equal to the percentage of time that the insipient failure is identified before actual failure.

In the second case, both functions and failure modes already exist. Adding the prognostic prediction in this case means breaking existing failure modes into two or more pieces. One piece represents the percentage of time that the failure occurs suddenly without prior detection through trending, while other pieces represent those percentages of time that a trend is identified first.

Flow of Design Information

Next, it is vital to ensure that information flows smoothly from requirements through to deployment. The initial requirements that are best derived from a Concept of Operations (ConOps) document should flow out to the logistics and resource allocation, as well as into the design of the diagnostics/prognostics solution itself. The following figure identifies one view of how information is utilized:



Notice that there is a essentially a struggle between good and bad behavior identified in by the green and red rows, which ultimately end in either mission success or mission failure. First, the design's inherent failures are identified in a FMECA. Next, the system's capabilities exist to support actions, while system constraints (limitations) can be shown to have consequences, as support by the FMECA. Identify that constraints have been violated is the role of diagnostics, while predicting that constraints are about to be violated is the role of prognostics. As such, both diagnostics and prognostics represent a "reasoning" capability that exists to provide intelligent remediation.

Moving further to the right in the diagram, the ability to remediate failure by finding alternative actions will ultimately lead to whether or not the mission succeeds or not. In the best case, the mission can still succeed due to full redundancy. Least desirable is the inability to remediate that results in a mission failure. Finally, diagnostics and/or prognostics again exists between the two to help provide a degraded mission option when mission success is not possible given a particular failure.

Systems Diagnostics and eXpress Training at Alabama A&M University

This past January was not only the beginning of a new semester at Alabama A&M, it also marked the first time that DSI officially held a certified Systems Diagnostics and ***eXpress*** training course in a University campus laboratory. Under the sponsorship of Alabama A&M University and Dr. Andrew Scott, (also attended by Dr. Alvernon Walker of North Carolina A&T), DSI International conducted the first three Systems Diagnostic courses using the University's ***eXpress*** Software. DSI instructors, Mr. Jim Lauffer and Mr. Eric Gould, successfully presented detailed information and examples using ***eXpress*** as a Systems engineering process and Diagnostic development / Prognostic data gathering tool. Mr. Lauffer, with a very extensive background in Logistic Support and Systems Engineering, instructed the class in the process of Systems Engineering as part of the Course 100 curriculum. Mr. Gould, DSI's Senior Software Architect and Algorithm Scientist, instructed Courses 110 and 120, while providing the class with insight to ***eXpress'*** diagnostic reasoning and robust diagnostic reporting mechanisms.

The goal of this class was to introduce the development of diagnostics and prognostics as they relate to the Systems Engineering process and the critical role of insightful diagnostics. While using ***eXpress***, students learned how design decisions are influenced through trade-off studies and operational system simulation techniques using ***eXpress***, DSI's new Simulation Module, and/or other existing, third-party, diagnostic/prognostic information producing/gathering tools.

In conclusion, DSI would like to extend a very warm "thank you" to Dr. Scott and Alabama A&M for providing us an excellent venue whereby we could successfully bring together both industry and academia together, in a common forum, and share the latest experiences, techniques, value and critical roles of ***eXpress*** diagnostics as it is applied to the most complex systems around the world today, and into the future!

Training Schedule

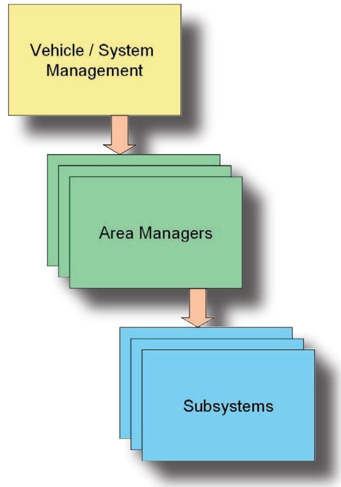
Course Number	Pre-requisite	Course Description	Dates	Location	POC
100		System Diagnostics Concepts and Applications	14 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
110		Basic Modeling & Introduction to Testing	14 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
120	110	Introduction to Testing & Analysis	17 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
200	120	Advanced Diagnostic Development & Assessment	21 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
205	200	Advanced Test Development & Importing	23 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
210	205	Advanced FMECA Development & Assessment	25 Mar, 2005	Orange, CA	Denise Aguinaga , DSI
100		System Diagnostics Concepts and Applications	25 Apr, 2005	Orange, CA	Denise Aguinaga , DSI
110		Basic Modeling & Introduction to Testing	25 Apr, 2005	Orange, CA	Denise Aguinaga , DSI
120	110	Introduction to Testing & Analysis	28 Apr, 2005	Orange, CA	Denise Aguinaga , DSI
200	120	Advanced Diagnostic Development & Assessment	16 May, 2005	Orange, CA	Denise Aguinaga , DSI
205	200	Advanced Test Development & Importing	18 May, 2005	Orange, CA	Denise Aguinaga , DSI
210	205	Advanced FMECA Development & Assessment	20 May, 2005	Orange, CA	Denise Aguinaga , DSI

IVHM Design Using eXpress

Top-Down Health Management - A familiar cry heard with most any description of ***eXpress***, is “top-down!”. ***eXpress*** can handle both top-down and bottom-up, but it is its top-down capabilities that set it apart. This is especially true for IVHM (Integrated Vehicle Health Management) design because the very notion of IVHM is a system-wide coordinated approach towards fault reporting, diagnosis and remediation. It’s worth noting that IVHM solutions are synonymous with those of ISHM (Integrated System Health Management, IPHM (Integrated Prognostic Health Management) or IAHM (Integrated Autonomous Health Management). Regardless of the acronym, the ultimate goal is the same; to manage the health of a given system.

Although the roots of IVHM are in the safety world, IVHM has quickly moved into the maintenance world as well. The benefits it can bring to such a wide range of problems, also pushes it to the forefront of any effort. The challenges to the design team are in proving IVHM’s merit to ensure it brings the maximum benefit, and does not get thrown onto the chopping block.

Shown to the right is a typical solution to handling both safety critical items that often require immediate reaction, as well as important, but non real-time functions, such as trending analysis. The vehicle/system management functions tend to be broader functions that factor in the mode of operation, while the area manager functions handle things like engine management, where hundredths of a second count.



It is these types of architecture decisions that must be assessed, fairly quickly within a systems engineering process, in order to support early, proper decision-making.

eXpress brings a unique ability to this problem. As various architectures emerge for implementing the solution, how quickly can you determine the impacts (detection rates, false removals, support costs, etc.) that might be expected with that approach? This is the problem that ***eXpress*** solves by providing the user with the ability to iteratively evaluate alternative concepts and design approaches right from the start.

For the complete article on this topic and other, please see our website at www.dsiintl.com

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As the leading seller of Diagnostic Software & related Diagnostic Engineering Services, DSI understands the importance of quality service and support. To meet the needs of our customers, we offer a wide array of technical support and service programs developed to address the time-critical issues and stringent diagnostic requirements revalent on many of today’s programs. DSI is ready to help with specialized software development, diagnostic modeling and analysis, prognostics and integration with any embedded Run-Time, integrated health managment (IVHM, ISHM, IPHM, etc.), advanced mentoring, data management processes and a host of customizable support services to address specific customer needs.

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