Integration of Diagnostics and Prognostics

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Full Systems Solution Though Teaming

DSI is teaming with Impact Technology to bring a true integration of Diagnostics and Prognostics

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eXpress Diagnostics Analysis vs. Prognostics Technology

eXpress Capability	Prognostic Capability
Determines failure mechanisms for entire function or system	Physics of Failure for time domain failure modes
Diagnostic and Prognostic test placement	Trend Analysis based on effective algorithms and event history for specific failure mode
Calculated and predicted remediation actions based on Reliability Weighted Diagnostics	Real-Time failure-based analysis based on condition events for time domain failure modes
Simulation-based Calculations	Run-time analysis based calculations

Diagnostics

- The process of identifying the occurrence of failures within a system, device or process using:
  - ✓Measurements of System Behavior
  - ✓Results of Autonomous Tests
  - ✓Results Driven from Empirical Analysis

- Diagnostic Analysis is the process of determining the fault detection and isolation capability of a System, Device or Process, with a known confidence level, at any level of the system hierarchy

Prognostics, or Predictive Diagnostics

- The process of predicting the occurrence of failures to a system, device or process based on predictable time domain failures
  - ✓such as mechanical wear or stress

- This is in contrast to non-time domain, random failures that cannot be prognosed using known technology
  - ✓such as electronic failures*

* Note: There is much research in work related to electronic prognostics and the use of surrogate environmental type sensors in electronic equipment / devices.

Run-Time Reasoners

- Can be effectively developed from the diagnostics design knowledge within ***eXpress™***
- Take information from the embedded diagnostics sensor and prognostics algorithm information
- Provides knowledge for system health management decisions
- Model Based, Case Based, Rule Based or other type of reasoning

Integrated System / Prognostic Health Management (ISHM / IPHM)

- An approach to Health Management that is based on:
  - ✓System Diagnostic Observability
  - ✓Prognostic Monitoring of predictable events
  - ✓Integration with Health Management decision Reasoners and run-time functional monitoring

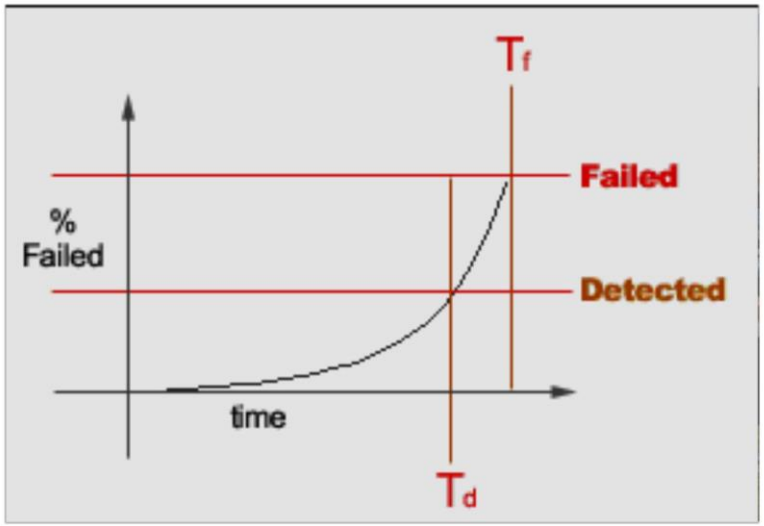
Prognostics Effectiveness

Effective Prognostics Test = Ability to detect a functional anomaly in time for the system to reconfigure to avoid the failure

Prognostic Tests Must Include:

- Ability to observe failure mechanism
- Ability to determine percent towards failure from the point the anomaly is detected

Prognostics from Detection to Remediation prior to Failure



T_f = Time of Failure
T_d = Time of Prognostics Detection
Failed = 100% Failure
Detected = % at which Trend is recognized

By recording the percentage* at which the trend is detected by prognostics, the time to failure (and therefore, the time in which to react) is then calculated using:

Time to Failure = $T_f - T_d$

*Note: The prognostic curve is shown for simplicity of discussion and is not typically a predictive curve as shown. The time to failure is based on prognostic algorithms combined with Condition Based event history. This differs from diagnostics which is based on Reliability weighted diagnostics analysis. The predictive prognostics is applicable to time domain failure events.

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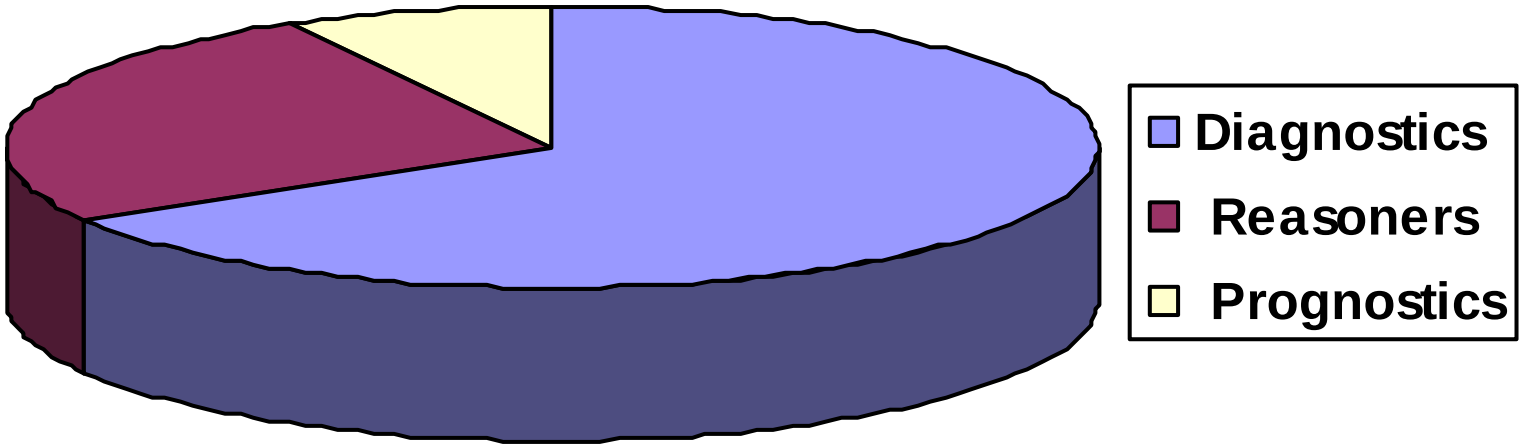
ISHM / IPHM
Theoretical Mix of an Embedded Health Management Knowledge Base



An Estimated Ratio of the Diagnostics, Prognostics and Reasoning Needed for an Effective Run Time Health Management System

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Conclusion

- DSI is teaming with Impact Technology to provide an Integrated Approach to Diagnostics and Prognostics in the Systems Engineering Process
- You must understand the System's Requirements before beginning a Diagnostics / Prognostics Design
- Start the Diagnostics and Prognostics Analysis Process as Soon as Possible
  - ✓ The Earlier the Better
  - ✓ But – It is Never Too Late to Start