Introduction to Diagnostic Engineering using the ISDD Tool Suite

January 2020
Who We Are
DSI International
40 Years of Diagnostic Engineering

- **Logic Modeling** (1978)
  - MIL-M-24100B
    - Functionally-Oriented Maintenance Manuals (1974)

- **LOGMOD** (1978)
  - MIL-STD-2165
    - Testability (1985)

- **STAT** (1988)
  - MIL-HDBK-1814
    - Integrated Diagnostics (1991)

- **eXpress** (1998)
  - IEEE 1522

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### Current U.S. Customers

**Aerospace & Defense**
- BAE Systems
- Boeing
- General Atomics
- General Dynamics
- Honeywell
- Lockheed Martin
- Northrop Grumman
- Raytheon
- Sikorsky

**Government**
- U.S. Army
- U.S. Navy
  - NAVAIR/NAVSEA

**Commercial**
- GE Transportation
- Thermo King

Over 500 licenses sold worldwide

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## International Customers

### Europe
- SPHEREA [FR / UK]
- MBDA [FR / UK]
- NEXTER (GIAT) [FR]
- Safran (SAGEM / Zodiak) [FR]
- THALES [FR]
- French DGA

### Asia
- Aviation Technologies (China)
- Dongfanghong Aircraft (China)
- Ishikawajima HI (Japan)
- Kingswell Enterprises (China)
- Mitsubishi HI (Japan)
- Shiji Electronics (China)
- Tianwei Industry (China)
- Xi’an Industries (China)
- Yuntong Technology (China)

### Middle East
- Hewlett-Packard (Israel)
DSI Has Extensive Experience on Major Programs

- 2nd Gen RLV
- Future Combat Systems
- CVN-76 Nimitz-Class Supercarrier
- Comanche Helicopter
- AIM-9X Evolved Sidewinder Missile
- F-35 (JSF)
- TSAT Satellites
- X-33 VentureStar
- Fire Scout UAV
- New Evolution Locomotive
- Eurofighter
- Space Operations Vehicle (SOV)
- Crusader Self-Propelled Howitzer
Recent Programs That Have Used eXpress

- JLENS (Raytheon)
- Global Hawk (Northrop)
- CH-53K (Sikorsky)
- JASSM (Lockheed)
- GCV (BAE Systems)
- Predator – MTS (Raytheon)
- X-Band Radar (Raytheon)
- IBCS (Boeing / Northrop)
- Standard Missile (Raytheon)
Current Programs Using eXpress

- Triton (Northrop)
- Small Diameter Bomb SDB-II & III (Raytheon)
- CVN-78 – EMALS/AAG (General Atomics)
- Bradley Vehicle (BAE Systems)
- KC-767 Refueling Tanker (Boeing)
- Standard Missile (Raytheon)
What We Do
Four Main Goals of Diagnostic Engineering

Availability

Cost of Ownership

Mission Success

Safety

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Subsidiary Benefits of Diagnostic Engineering

**Availability**
- Effective Isolation to Optimum Repair Level
- Lower MTTI / MTTR
- Improved MTBF
- Improved Fault Detection
- Reduced False Alarms
- Reduced System / Mission Aborts

**Cost of Ownership**
- Reduced False Removals
- Lower Maintenance Costs
- FMECA / Fault Tree Analysis
- Probabilistic Risk Assessment
- Unique Isolation of Critical Failures

**Mission Success**

**Safety**

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Fault Detection & Isolation in eXpress

Detection Order Report

Summary

- Total Detection Tests: 17
- Total Functions Detected: 92.68%
- Total Probability Detected: 97.34%

Aggregate Failure Rate: 34634.054901
Mean Time Between Failures (MTBF): 28.87 hours

Fault Isolation Report

Multiple Failure Fault Group Size Statistics

<table>
<thead>
<tr>
<th>Size</th>
<th>Qty</th>
<th>Isolation Percentages Using Testing Only</th>
<th>Resolution Probabilities Using Lambda Search</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Isolation Percentages Using Testing Only</td>
<td>Isolation Percentages Using Testing Only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>77</td>
<td>78.57</td>
<td>81.04</td>
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<tr>
<td>2</td>
<td>11</td>
<td>11.22</td>
<td>89.80</td>
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<td>3</td>
<td>0</td>
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<td>4</td>
<td>0</td>
<td>0.00</td>
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<td>5</td>
<td>2</td>
<td>2.04</td>
<td>91.84</td>
</tr>
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<td>6</td>
<td>0</td>
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<td>7</td>
<td>7</td>
<td>7.14</td>
<td>98.98</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>1.02</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Simulation-based Analysis in STAGE
Fault Detection in STAGE

- Detected Failures
- Non-Detected Failures

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Fault Isolation in STAGE

- Isolation to Multiple LRUs
- Isolation to a Single LRU
False Alarms in STAGE

- Non-Alarm Faults
- Operational (True) Alarms
- Isolated Diagnostic Alarms
- Diagnostic False Alarms

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System/Mission Aborts in STAGE

False System/Mission Aborts

True System/Mission Aborts

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Unambiguous vs. Unique Isolation

Ambiguous Isolation
(Multiple Items)

Unambiguous Isolation
(Single Item)

Unique Isolation
(Root Cause(s) of Single Failure)

Item A
FM-1
FM-2

Item B
FM-1
FM-2

Item A
FM-1
FM-2

Item B
FM-1
FM-2

Item A
FM-1
FM-2

Item B
FM-1
FM-2

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<table>
<thead>
<tr>
<th>Failure</th>
<th>Item</th>
<th>Failure Rate</th>
<th>Severity Class</th>
<th>Relative Criticality</th>
<th>Diagnostic Coverage</th>
<th>Fault isolation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic Leak</td>
<td>FS Line</td>
<td>38.026486</td>
<td>Loss of Life</td>
<td>38.0265</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hydraulic Leak</td>
<td>FR Line</td>
<td>38.026486</td>
<td>Loss of Life</td>
<td>38.0265</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Forward Pump Failure</td>
<td>Front Pump</td>
<td>19.013243</td>
<td>Loss of Life</td>
<td>19.0132</td>
<td>No</td>
<td>N/A</td>
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<tr>
<td>Rear Pump Failure</td>
<td>Rear Pump</td>
<td>19.012853</td>
<td>Loss of Life</td>
<td>19.0129</td>
<td>No</td>
<td>N/A</td>
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<tr>
<td>L Brake Light Bulb Failure</td>
<td>L Brake Bulb</td>
<td>87.751626</td>
<td>Degraded Performance</td>
<td>17.5503</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>R Brake Light Bulb Failure</td>
<td>R Brake Bulb</td>
<td>87.751626</td>
<td>Degraded Performance</td>
<td>17.5503</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>W Brake Light Bulb Failure</td>
<td>RW Brake Bulb</td>
<td>87.751626</td>
<td>Degraded Performance</td>
<td>17.5503</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Battery dead</td>
<td>BATTERY</td>
<td>41.639002</td>
<td>Loss of Operation</td>
<td>16.6556</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Solenoid Control Relay Coil Open</td>
<td>Solenoid Relay</td>
<td>11.573041</td>
<td>Loss of Life</td>
<td>11.5730</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Gallery Fuse Blown</td>
<td>Fuse</td>
<td>11.407946</td>
<td>Loss of Life</td>
<td>11.4079</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Pump Relay Cotact Stuck Open</td>
<td>Pump Relay</td>
<td>11.129475</td>
<td>Loss of Life</td>
<td>11.1295</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Brake Light Switch Stuck Open</td>
<td>Brake Light SIV</td>
<td>9.919748</td>
<td>Loss of Life</td>
<td>9.9197</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Ped1 Wear Beyond Limit</td>
<td>LR Disc Assy PADS</td>
<td>9.393685</td>
<td>Loss of Life</td>
<td>9.3937</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ped1 Wear Beyond Limit</td>
<td>LF Disc Assy PADS</td>
<td>9.393685</td>
<td>Loss of Life</td>
<td>9.3937</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ped1 Wear Beyond Limit</td>
<td>RR Disc Assy PADS</td>
<td>9.393685</td>
<td>Loss of Life</td>
<td>9.3937</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Ped1 Wear Beyond Limit</td>
<td>RF Disc Assy PADS</td>
<td>9.393685</td>
<td>Loss of Life</td>
<td>9.3937</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Tread Worn</td>
<td>LR Tire</td>
<td>45.000000</td>
<td>Degraded Performance</td>
<td>9.0000</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Worn Tread</td>
<td>RF Tire</td>
<td>45.000000</td>
<td>Degraded Performance</td>
<td>9.0000</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Worn Tread</td>
<td>LF Tire</td>
<td>45.000000</td>
<td>Degraded Performance</td>
<td>9.0000</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Worn Tread</td>
<td>RR Tire</td>
<td>45.000000</td>
<td>Degraded Performance</td>
<td>9.0000</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>Pedal Linkage Failure</td>
<td>Brake Pedal</td>
<td>8.577227</td>
<td>Loss of Life</td>
<td>8.5772</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Ignition Switch Stuck Open</td>
<td>Ignition Switch</td>
<td>8.415525</td>
<td>Loss of Life</td>
<td>8.4155</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Solenoid Control Relay Contact stuck ATCM</td>
<td>Solenoid Relay</td>
<td>7.68196</td>
<td>Loss of Life</td>
<td>7.6819</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Solenoid Control Relay Contact stuck GND</td>
<td>Solenoid Relay</td>
<td>7.68196</td>
<td>Loss of Life</td>
<td>7.6819</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hydraulic Leak</td>
<td>RS Line</td>
<td>38.027272</td>
<td>Degraded Performance</td>
<td>7.6055</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hydraulic Leak</td>
<td>RR Line</td>
<td>38.027272</td>
<td>Degraded Performance</td>
<td>7.6055</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The “Uniquely Isolated” column indicates whether the fault group that is isolated for this failure contains only root causes of the given failure. If the fault group contains any failure modes that are not a root cause of that failure, then the failure has not been uniquely isolated by the diagnostics. The non-unique isolation of critical failures is a primary driver of false alarms and unnecessary system or mission aborts.
Critical Event 2.0
Loss of Anti-Lock Braking

Event 2.1
Brake Pressure Loss
   - Q: 2.151E-007
   - FD: 100.00%
   - FUE: 99.61%

Event 2.2
ECU Failure
   - Q: 1.152E-008
   - FD: 92.64%
   - FUE: 0.90%

Event 2.3
Failure to Anti-Lock Brakes
   - Q: 8.149E-008
   - FD: 81.81%
   - FUE: 13.89%

Event 2.1.1
Failure due to Hydraulic Leak
   - Q: 2.140E-007
   - FD: 100.00%
   - FUE: 100.00%

Primary Failure 2.1.2
Master Cylinder Failure
   - Q: 1.100E-009
   - FD: 100.00%
   - FUE: 3.98%

FR: 0.792
What is ISDD?
ISDD: Modeling and Analysis

- **Design Import Manager**
  - eXpressML Module
  - FMECA Plus
  - FTA Module

- **eXpress**
  - Prognostics Module
  - Maintenance Module
  - DFI

- **STAGE**
  - Simulation-Based Trade Studies, Presentation-Ready Graphics
  - Diagnostic Analysis & Reports

- **Interoperability**
  - eXpressML
  - DiagML
  - Proprietary DSI Formats
  - Other Industry Formats
  - Tight Integration

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ISDD: Diagnostic Development & Deployment

- eXpress
  - Dynamic Diagnostics Module
  - TRD Module
  - Maintenance Module
  - eXpress Design Viewer (freeware)
  - Design Viewer Redline Module
  - DSI Dynamic Reasoner with TestDRIVE
  - DSI Embedded Reasoner with TestDRIVE

- RTAT
  - D-Matrix Export Module
  - Health Management Platform, ATE, etc.

- Interoperability
  - eXpressML
  - DiagML
  - Proprietary DSI Formats
  - Other Industry Formats
  - Tight Integration

- Empirical Data
  - Third-party Test Executive
  - Relational Database

- Other Industry Formats
  - ISDD: Diagnostic Development & Deployment

- Third-Party Diagnostic Executive

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#### The ISDD Tool Suite

<table>
<thead>
<tr>
<th><strong>eXpress</strong></th>
<th><strong>Diagnostic Modeling and Analysis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>eXpress</em> creates the models used by all tools in the ISDD tool suite. It also performs standardized analyses to help engineers optimize and assess system diagnostics/prognostics, as well as the design’s ability to support effective HM.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>STAGE</strong></th>
<th><strong>Simulation-based Analysis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Using data from <em>eXpress</em>, STAGE simulates failures, diagnoses and repairs that would occur in a fielded system. Calculations (represented as graphs) show changes over time, as well as the impact of maintenance upon failure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RTAT</strong></th>
<th><strong>Enhancing Exported Diagnostics</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The <em>eXpress Run-Time Authoring Tool (RTAT)</em> allows diagnostic procedures exported from <em>eXpress</em> to be enhanced with graphic overlays and links to external documents. Diagnostics can also be reformatted for use in a variety of tools. This tool includes the <em>eXpress</em> Design Viewer.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DSI Workbench</strong></th>
<th><strong>Run-Time Diagnostic Executive</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>DSI Workbench</em> allows diagnostics developed in <em>eXpress</em> to be fielded in a maintenance or production environment. <em>DSI Workbench</em> supports integration with a test executive, as well as guided troubleshooting and free-form test entry.</td>
</tr>
</tbody>
</table>

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**eXpress Modules**

**Diagnostic Modeling and Analysis**
eXpress creates the models used by all tools in the ISDD tool suite. It also performs standardized analyses to help engineers optimize and assess system diagnostics/prognostics, as well as the design’s ability to support effective HM.

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMECA Plus (eXpress Reliability Module)</td>
<td>Module that allows FMECA data (either imported or developed in eXpress) to be enhanced with metrics derived from eXpress diagnostics. Automatically included with all eXpress licenses.</td>
</tr>
<tr>
<td>eXpress FTA Module</td>
<td>Fully integrated with FMECA Plus and the eXpress diagnostics, this module allows eXpress to produce diagnostic/prognostic-informed fault trees for Reliability and Safety analysis.</td>
</tr>
<tr>
<td>eXpress Prognostics Module</td>
<td>Module that allows eXpress to analyze the impact of prognostics upon diagnostic performance. Prognostic definitions can also be exported to be used in trade studies within STAGE.</td>
</tr>
<tr>
<td>eXpress Maintenance Module</td>
<td>Module that allows eXpress to support multiple levels of diagnosis. It has been designed to facilitate the concurrent development of embedded diagnostics and troubleshooting procedures (IETMs).</td>
</tr>
<tr>
<td>eXpress Dynamic Diagnostics Module</td>
<td>Module that allows eXpress to export resource files to be used by the eXpress Dynamic Reasoner. It also allows Dynamic Diagnostics to be validated using the eXpress Desktop Fault Insertion capability.</td>
</tr>
</tbody>
</table>

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RTAT and Design Viewer Modules

Enhancing Exported Diagnostics
The *eXpress Run-Time Authoring Tool* (RTAT) allows diagnostic procedures exported from *eXpress* to be enhanced with graphic overlays and links to external documents. Diagnostics can also be reformatted for use in a variety of tools.

**D-Matrix Export Module**
Plug-in module that allows RTAT to export test dependency data from *eXpress* in a Dependency Matrix format.

**eXpress Design Viewer Redline Module**
Plug-in module that allows users to add comments and feedback within the *eXpress* Design Viewer.

**eXpress Design Viewer**
The *eXpress Design Viewer* allows design and diagnostic data to be shared and/or reviewed on systems where *eXpress* has not been installed. This not only facilitates team collaboration and in-house reviews, but also provides a deliverable for customer evaluation.

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## Diagnostic Engineering Applications

### Design Assessment & Influence

- Assess ability to meet contracted requirements
- Optimize design for effective supportability
- Support interoperability with other model-based design activities

### Diagnostic Development & Deployment

- Generate optimized diagnostics based on eXpress analysis
- Link HM to troubleshooting and/or maintenance procedures
- Determine successful mixes of corrective, predictive and periodic maintenance.

### New Systems

- Identify weaknesses in current diagnostic capability
- Generate case studies evaluating the impact of proposed upgrades
- Create models to incorporate into MBSE databases

### Legacy Systems

- Improve existing diagnostics based on eXpress analysis
- Repurpose existing diagnostics for new run-time platforms
- Develop empirical diagnostics from field analytics

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Model-based Sustainment
How We Do It
Hierarchical System Model

- Linked models representing different levels of indenture in the system hierarchy
- Diagnostic & FMECA/FTA analyses can be performed for (and to) any level of the hierarchy
Dependency-Based Test Definitions

- Test coverage defines what diagnostics “learns” when a test passes or fails
- Initially, coverage can be based upon the modeled dependencies
- Test definitions can be reviewed both graphically and in the Explorer tree
Hierarchical Diagnostics

- Diagnostic Sequences can be developed for different levels of the system hierarchy.
- You can descend within the hierarchy to view suspected elements or isolated fault groups at different levels of indenture.
Diagnostic / Design Assessment

- *eXpress* reports provide a variety of analysis results, designed to help you meet diagnostic requirements for testability, reliability, system availability, maintainability and safety.
Integration of Functional & Failure Propagation

- **Functional Propagation** (horizontal) model
  Functional dependencies show how functions are impacted by other functions.
  Relationship settings show how functions are impacted by specific failure modes.

- **Failure Propagation** (vertical) model
  Failure effects show how failure modes manifest themselves at different design levels
Diagnostics-Informed Reliability Analysis

- FMEA/FMECA charts can be developed within **eXpress** or imported from external tools.
- **eXpress** FMECA charts can contain a variety of columns detailing how and when failures are detected and isolated by the actual diagnostics.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Value</th>
<th>Failure</th>
<th>Failure Effects</th>
<th>Severity</th>
<th>Failure Rate</th>
<th>Diagnostic Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1004 TB</td>
<td>SURFACED MOUNT</td>
<td>TC4-1W7A41+</td>
<td>Open</td>
<td>RF out channel 1 + J11 failed for U43 Out C DSP only</td>
<td>Category 1 - Catastrophic</td>
<td>Failure Detected</td>
<td></td>
</tr>
<tr>
<td>1005 U1</td>
<td>IC REG LDO ADJ 5A 28QFN</td>
<td>LT3070MP0F</td>
<td>U1-OUT failed open</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1006</td>
<td></td>
<td></td>
<td>U1-OUT failed short</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1007</td>
<td></td>
<td></td>
<td>U1-power input failed short</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1008</td>
<td></td>
<td></td>
<td>U1-FWRED failed</td>
<td>Failure to monitor f12VIA voltage</td>
<td>Failure of all ADC channels</td>
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<tr>
<td>1009 U2</td>
<td>IC REG LDO ADJ 5A 28QFN</td>
<td>LT3070MP0F</td>
<td>U2-OUT failed open</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
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<td>1010</td>
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<td>U2-OUT failed short</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
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<tr>
<td>1011</td>
<td></td>
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<td>U2-power input failed short</td>
<td>DSP, f12VIA POWER FAILED</td>
<td>Failure of all ADC channels</td>
<td></td>
<td></td>
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<tr>
<td>1012</td>
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<td>U2-FWRED failed</td>
<td>Failure to monitor f12VIA voltage</td>
<td>Failure of all ADC channels</td>
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<td>1013 U3</td>
<td>High Performance Wide Band PLL wth Integrated VCO</td>
<td>LMX2582</td>
<td>Lock Detect Failed</td>
<td>Invalid indication of failure of U3 PLL lock</td>
<td>Category 1 - Catastrophic</td>
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<td>1014</td>
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<td>RF Output failed</td>
<td>Failure of ADC and interferences clocks</td>
<td>Failure of all ADC channels</td>
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<td>1015 U4</td>
<td>Ultra Low-Noise Clock After Cleaner wth Dual Loop PLLs w/ Enhanced Performance</td>
<td>LMK04828EP</td>
<td>PLL1 Failed</td>
<td>Invalid indication of failure of U4 input signal</td>
<td>Failure to communicate with U4 serial</td>
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<td>1016</td>
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<td>PLL2 Failed</td>
<td>Invalid indication of failure of U4 input signal</td>
<td>Failure to communicate with U4 serial</td>
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<td>REGISTERS Failed</td>
<td>Failure to communicate with U4 serial interface</td>
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<td>U4-DCLKOUTS - 1, 2, VCLK failed</td>
<td>Failure of ADC channel 1</td>
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<td>Failure of ADC channel 2</td>
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<td>Failure of ADC channel 3</td>
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<td>U4-DCLKOUTS - 4, VCLK failed</td>
<td>Failure of ADC channel 4</td>
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<td>U4-DCLKOUTS - 5, VCLK failed</td>
<td>Failure of ADC channel 5</td>
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<td>Failure of ADC channel 6</td>
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<td>Failure of ADC channel 7</td>
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<td>Failure of ADC channel 8</td>
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<td>Failure of ADC channel 9</td>
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<td>U4-DCLKOUTS - 10, VCLK failed</td>
<td>Failure of ADC channel 10</td>
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<td>Failure of ADC channel 11</td>
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<td>Failure of ADC channel 16</td>
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<td>1034 U5</td>
<td>FPGA, Aria 10, SX660, 45TXV, 55+125, F40 package</td>
<td>AT09DC_1517</td>
<td>ADC 0 Over Range 0 failed</td>
<td>Failure to indicate that ADC channel 0 is over range</td>
<td>Failure to detect</td>
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<td>ADC 0 Over Range 1 failed</td>
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<td>ADC 0 Voltage [0, 7] failed</td>
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<td>Failure of ADC channel 0</td>
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<td>ADC 1 Over Range 0 failed</td>
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<td>1038</td>
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<td>ADC 1 Over Range 1 failed</td>
<td>Failure to indicate that ADC channel 1 is over range</td>
<td>Failure to detect</td>
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</table>

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Diagnostics-Informed Fault Tree Analysis

- Fault Trees include diagnostic metrics that indicate how well diagnostics can detect and isolate individual failures that lead up to a critical event.
- Allows you to assess the overall Risk of having less-than-perfect diagnostics.

![Fault Tree Diagram](image-url)
Desktop Fault Insertion

- Consists of an interactive dialog and corresponding report
- Allows analysts to validate diagnostics developed in *Express* by examining how inserted faults are detected and isolated
- Provides a variety of features to support both in-house and customer reviews
- Supports the troubleshooting of issues identified during maintenance demos or for fielded systems
Diagnostic Interoperability via RTAT

- Additional Views, Hot Spots and Rules for Display
- Test & Repair Procedures, Graphics, Videos & Documentation
- Interoperability
  - DiagML
  - Proprietary DSI Formats
  - Other Industry Formats
  - Tight Integration

- eXpress Design Viewer (freeware)
- DSI Embedded Reasoner
- DSI Workbench
- History & Feedback Module
- Relational Database
- TRD Module
- Third-Party Industry Formats

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Diagnostic Deployment using DSI Workbench

Exporting Diagnostic Study

Integrating Diagnostic Study & Resources

Implementing Diagnostic Strategy in Run-Time Environment

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Run-Time Diagnostics in DSI Workbench

- DSI Workbench is a full-featured diagnostic executive for maintenance and production environments
- With minimal effort, you can field the same diagnostics you used to evaluate your system Testability
eXpress Fly-Over