

An Introduction to DSI and our Products

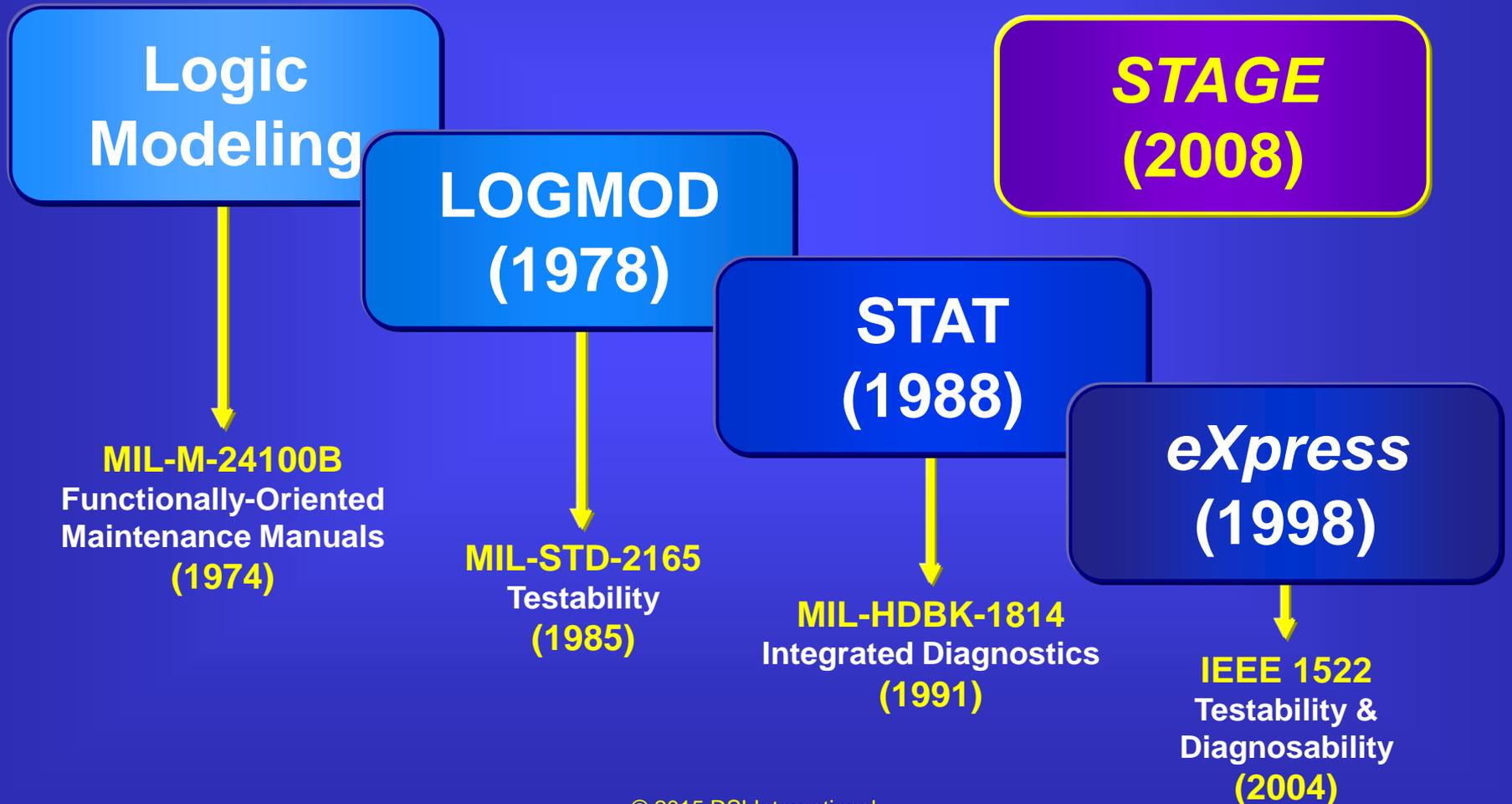


DSI International, Inc.

April, 2015

DSI International

40 Years of Diagnostic Engineering



DSI is the World's Leading Provider of Diagnostic Engineering Software

Current U.S. Customers

Major Companies

BAE Systems

Boeing

General Atomics

General Electric

General Dynamics

Honeywell

Lockheed Martin

Northrop Grumman

Raytheon

Sikorsky

Government

U.S. Army

U.S. Navy

- NAVAIR

- NAVSEA

Universities

North Carolina A&T

Alabama A&M

over 250 licenses sold
within the United States

DSI is the World's Leading Provider of Diagnostic Engineering Software

International Customers

Europe

EADS (European Union)
Eurocopter (France)
MBDA (France)
MBDA (U.K.)
Nexter / GIAT (France)
Sagem (France)
THALES (France)

Middle East

Hewlett-Packard (Israel)

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)

DSI Has Extensive Experience on Major Programs



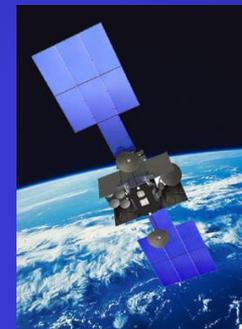
2nd Gen RLV



Future Combat Systems



Joint Strike Fighter



TSAT Satellites



CVN-76 Nimitz-Class Supercarrier



Comanche Helicopter



AIM-9X Evolved Sidewinder Missile



X-33 VentureStar



New Evolution Locomotive



Eurofighter



Space Operations Vehicle (SOV)



Crusader Self-Propelled Howitzer



Fire Scout UAV

Recent Programs That Have Used eXpress



JLENS (Raytheon)



BAMS (Northrop)



CH-53K (Sikorsky)



JASSM (Lockheed)



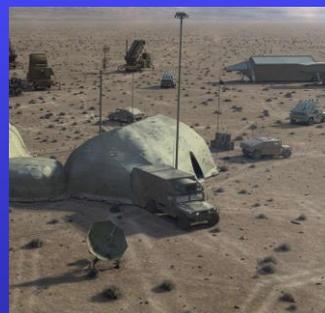
GCV (BAE Systems)



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)**



**KC-767 Refueling Tanker
(Boeing)**



**CVN-78 – EMALS/AAG
(General Atomics)**



**Bradley Vehicle
(BAE Systems)**



Standard Missile (Raytheon)

The Benefits of Integrated System Diagnostic Development (ISDD)

- ❖ Integrates Work from Multiple Disciplines
- ❖ Encourages Multi-Purposing of Data
- ❖ Promotes Use of Turnkey Data Solutions
- ❖ Reduces Redundant / Repeated Efforts



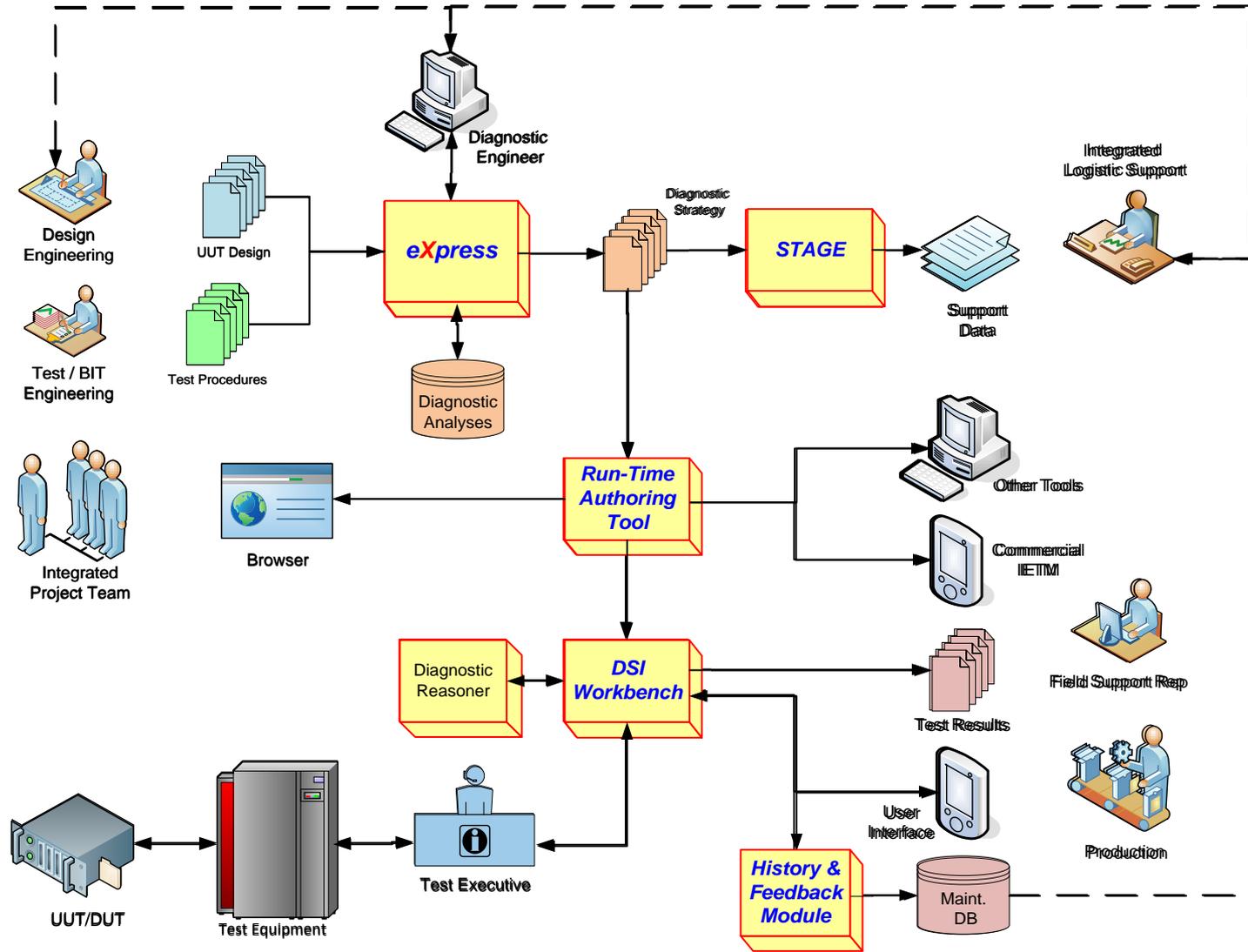
ISDD Encompasses All Aspects of Diagnostic Engineering

- ❖ Requirements Derivation & Allocation
- ❖ Design Development
- ❖ Test Point Enhancement
- ❖ Design & Diagnostic Optimization
- ❖ Risk & Safety Assessment
- ❖ Prognostic & Reasoner Development
- ❖ Embedded Systems Integration
- ❖ Life Cycle Support

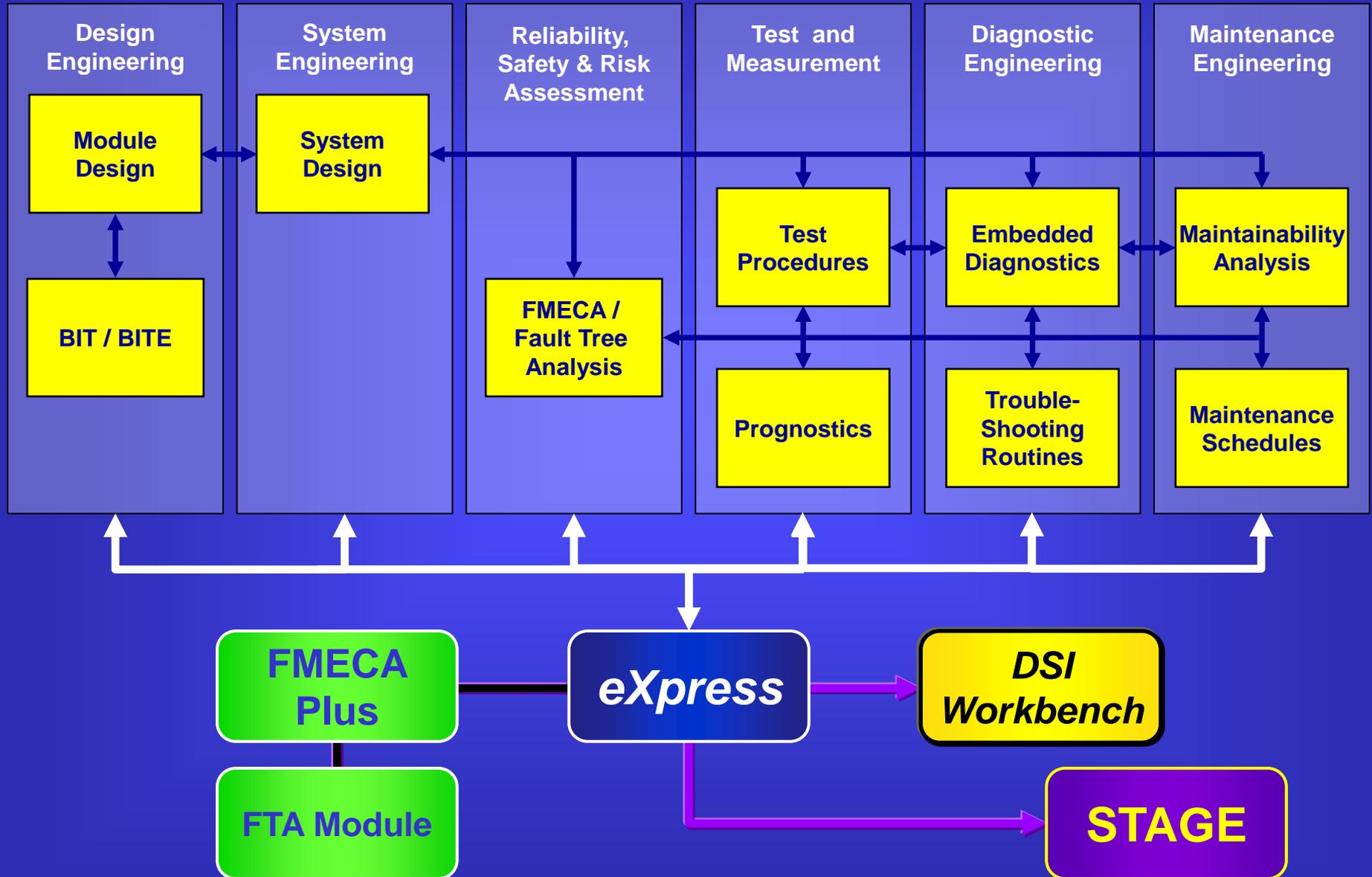
ISDD Can Benefit Both Military and Commercial Programs



ISDD and Diagnostic Engineering



ISDD is a Pan-Disciplinary Solution



The ISDD Tool Suite

eXpress

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.

**eXpress
FMECA Plus
Module**

Diagnostic FMECAs

The **eXpress FMECA Plus** module allows standard FMECA data (either imported from a commercial FMECA tool or developed within **eXpress**) to be enhanced with metrics derived from the **eXpress** diagnostics. This module is automatically included with each license of **eXpress**.

**eXpress
FTA
Module**

eXpress FTA Module

The **eXpress** FTA Module provides a set of features that allow **eXpress** to create and analyze reliability fault trees. Fully integrated with both **FMECA Plus** and the **eXpress** diagnostics, this module can produce diagnostic & prognostic-informed fault trees for Reliability and Safety analysis.

**eXpress
Maintenance
Module**

eXpress Maintenance Module

The **eXpress** Maintenance Module provides a set of features that allow **eXpress** to support multiple levels of diagnosis. It has been designed to facilitate the concurrent development of embedded diagnostics and troubleshooting procedures (IETMs).

STAGE

Simulation-based Analysis

Using data from **eXpress**, **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.

**eXpress
Run-Time
Authoring Tool**

Enhancing Exported Diagnostics

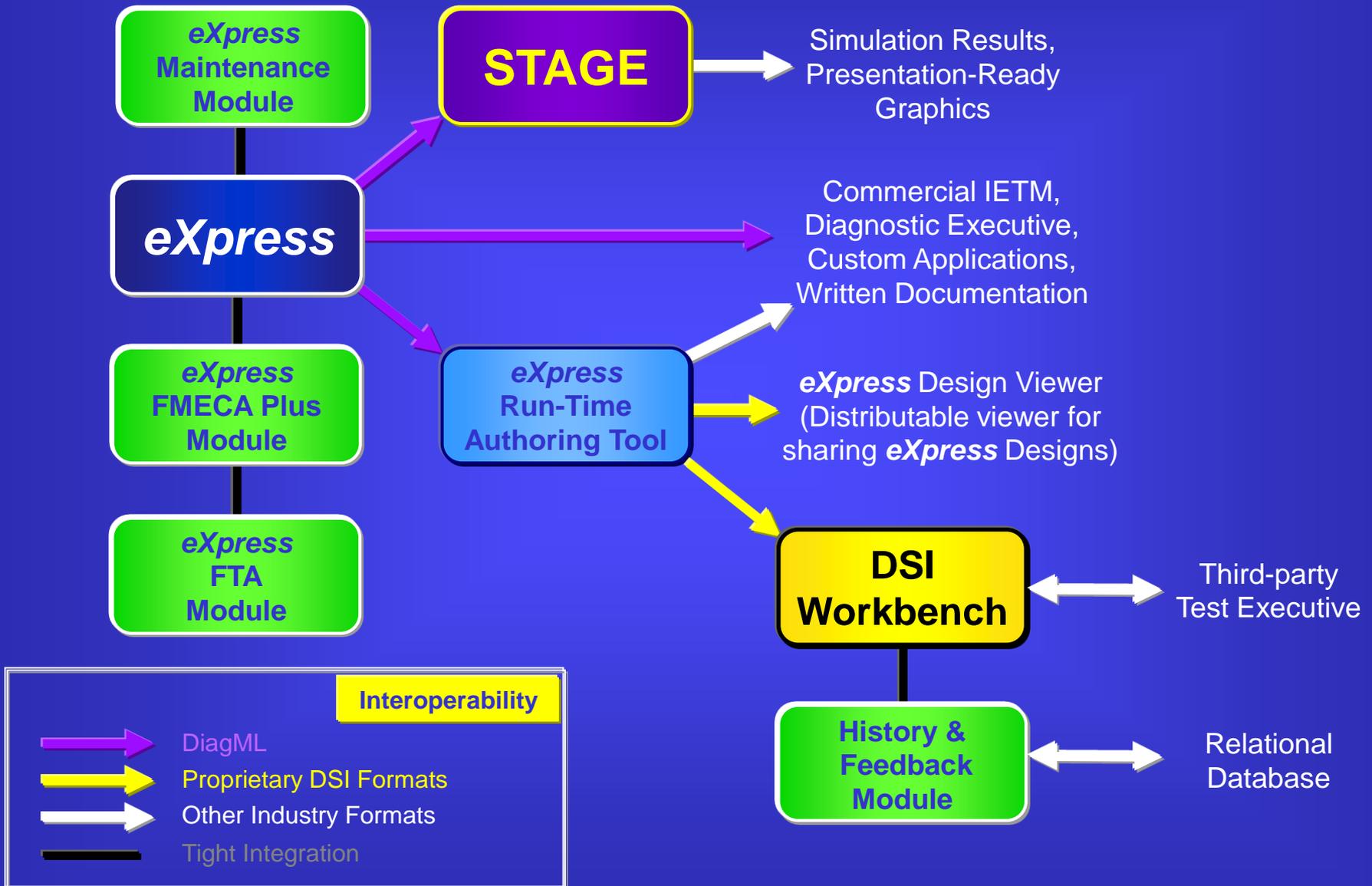
The **eXpress Run-Time Authoring Tool (RTAT)** allows diagnostic procedures exported from **eXpress** to be enhanced with graphic overlays and links to external documents. Diagnostics can also be reformatted for use in a variety of tools. This tool includes the **eXpress** Design Viewer.

**DSI
Workbench**

Run-Time Diagnostic Application

DSI Workbench allows diagnostics developed in **eXpress** to be fielded in a maintenance or production environment. DSI Workbench supports integration with a test executive, as well as guided troubleshooting and free-form test entry.

Integrated Systems Diagnostics Design (ISDD)



RTAT & DSI Workbench Tool Suite Modules

eXpress Run-Time Authoring Tool

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.

eXpress Design Viewer

eXpress Design Viewer

Free viewer that allows **eXpress** design and diagnostic data to be shared/reviewed on systems where **eXpress** has not been installed.

DSI Workbench

Run-Time Diagnostic Application

DSI Workbench allows diagnostics developed in **eXpress** to be fielded in a maintenance or production environment. DSI Workbench supports integration with a test executive, as well as guided troubleshooting and free-form test entry.

History & Feedback Module

History & Feedback Module

Fully-Integrated database that provides tracking of session history and feedback for heuristic applications.

ATML Module

ATML Module

Plug-in translator that allows **DSI Workbench** to read test results from files in **ATML** (IEEE Std. 1631.1-2007) format

PDEL (TOD) Module

PDEL (TOD) Module

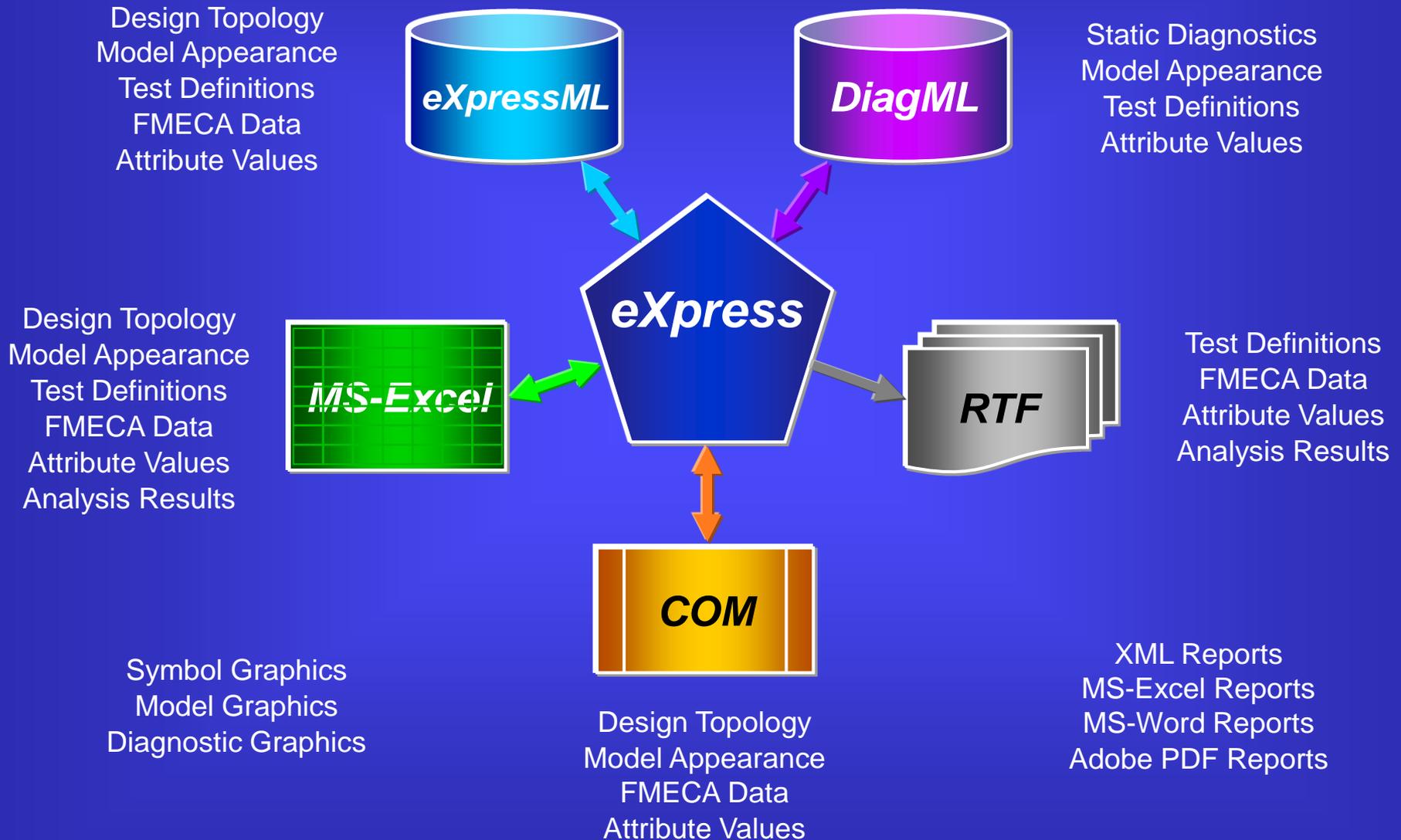
Plug-in translator that allows **DSI Workbench** to read test results from files in **PDEL/TOD** (IEEE Std. 1545-1999) format

API Module

API Module

Application Programming Interface (API) for use between **DSI Workbench** and the testing application

eXpress Interoperability

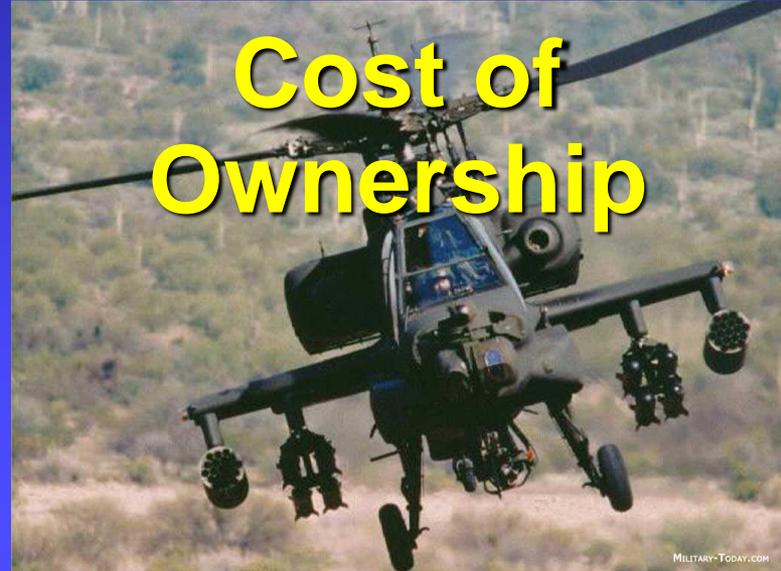


Four Main Goals of Diagnostic Engineering

Availability



Cost of Ownership



Mission Success



Safety



Subsidiary Benefits of Diagnostic Engineering

Availability

Cost of Ownership

Effective Isolation to Optimum Repair Level

Lower MTTI / MTTR

Reduced False Removals

Improved MTBF

Lower Maintenance Costs

Improved Fault Detection

Reduced False Alarms

FMECA / Fault Tree Analysis

Reduced System / Mission Aborts

Probabilistic Risk Assessment

Unique Isolation of Critical Failures

Mission Success

Safety

Contracted Diagnostic Requirements

Availability

**Cost of
Ownership**

**Effective Isolation to
Optimum Repair Level**

Improved Fault Detection

**Unique Isolation of
Critical Failures**

**Mission
Success**

Safety

Fault Detection & Isolation in eXpress

Detection Order Report

Summary

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

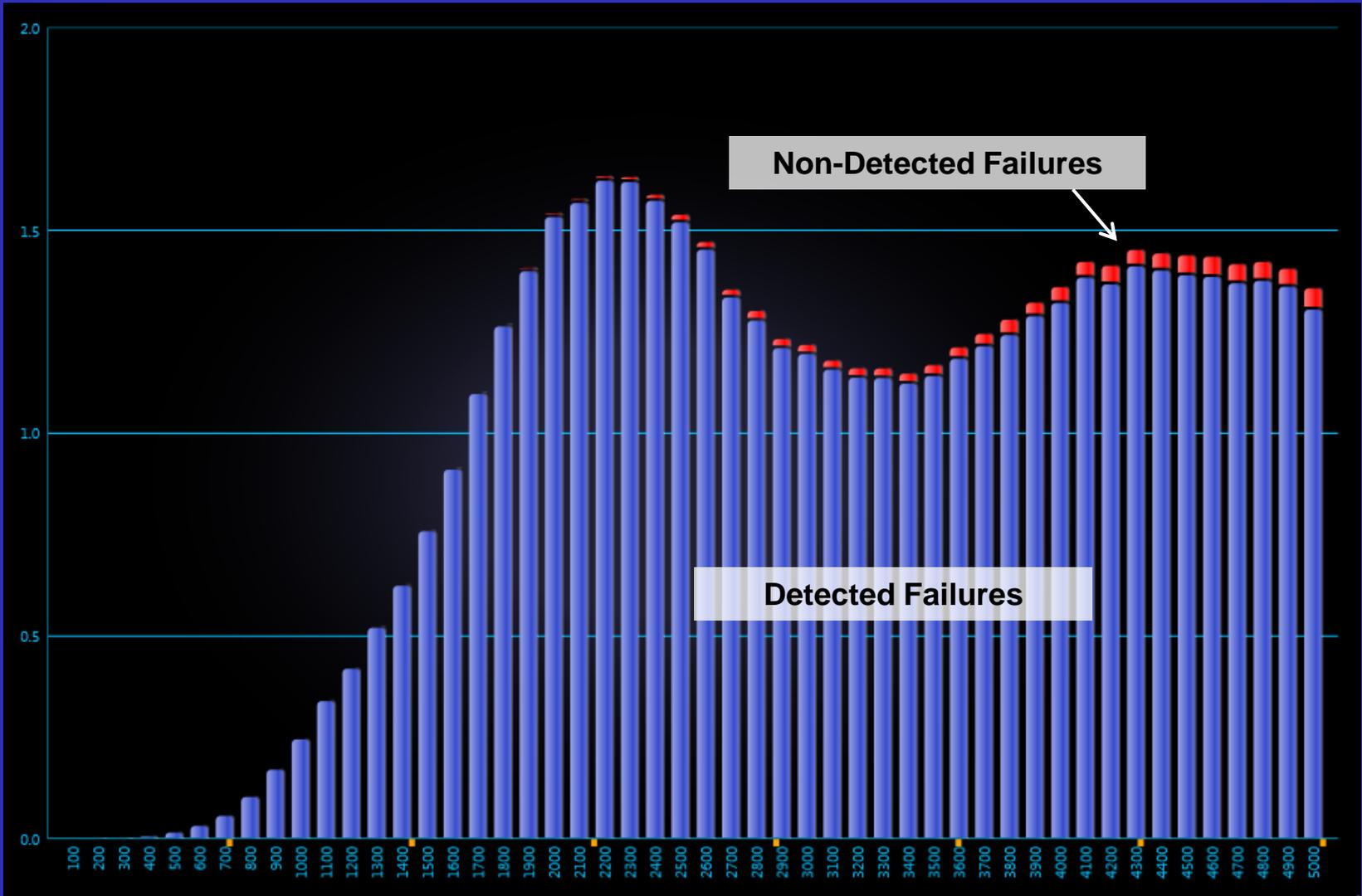
Aggregate Failure Rate: 34634.054901
Mean Time Between Failures (MTBF): 28.87 hours

Fault Isolation Report

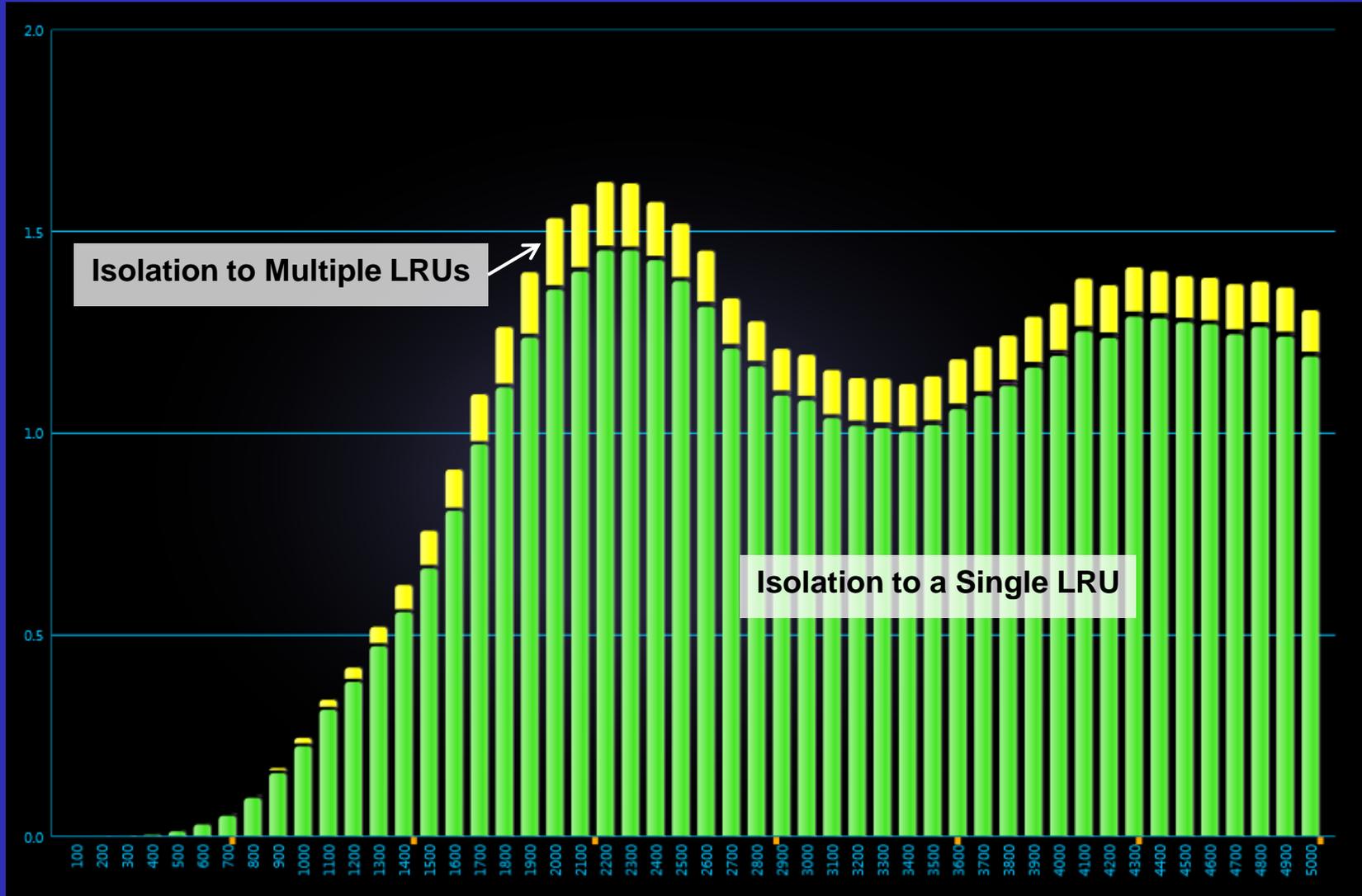
Multiple Failure Fault Group Size Statistics

Size	Isolation Percentages Using Testing Only			Isolation Probabilities Using Testing Only		Resolution Probabilities Using Lambda Search	
	Qty	%	Cum %	%	Cum %	%	Cum %
1	77	78.57	78.57	81.04	81.04	92.72	92.72
2	11	11.22	89.80	8.97	90.00	3.37	96.09
3	0	0.00	89.80	0.00	90.00	2.01	98.10
4	0	0.00	89.80	0.00	90.00	1.29	99.39
5	2	2.04	91.84	7.22	97.22	0.57	99.96
6	0	0.00	91.84	0.00	97.22	0.03	99.98
7	7	7.14	98.98	2.16	99.38	0.01	99.99
8	1	1.02	100.00	0.62	100.00	< 0.01	100.00

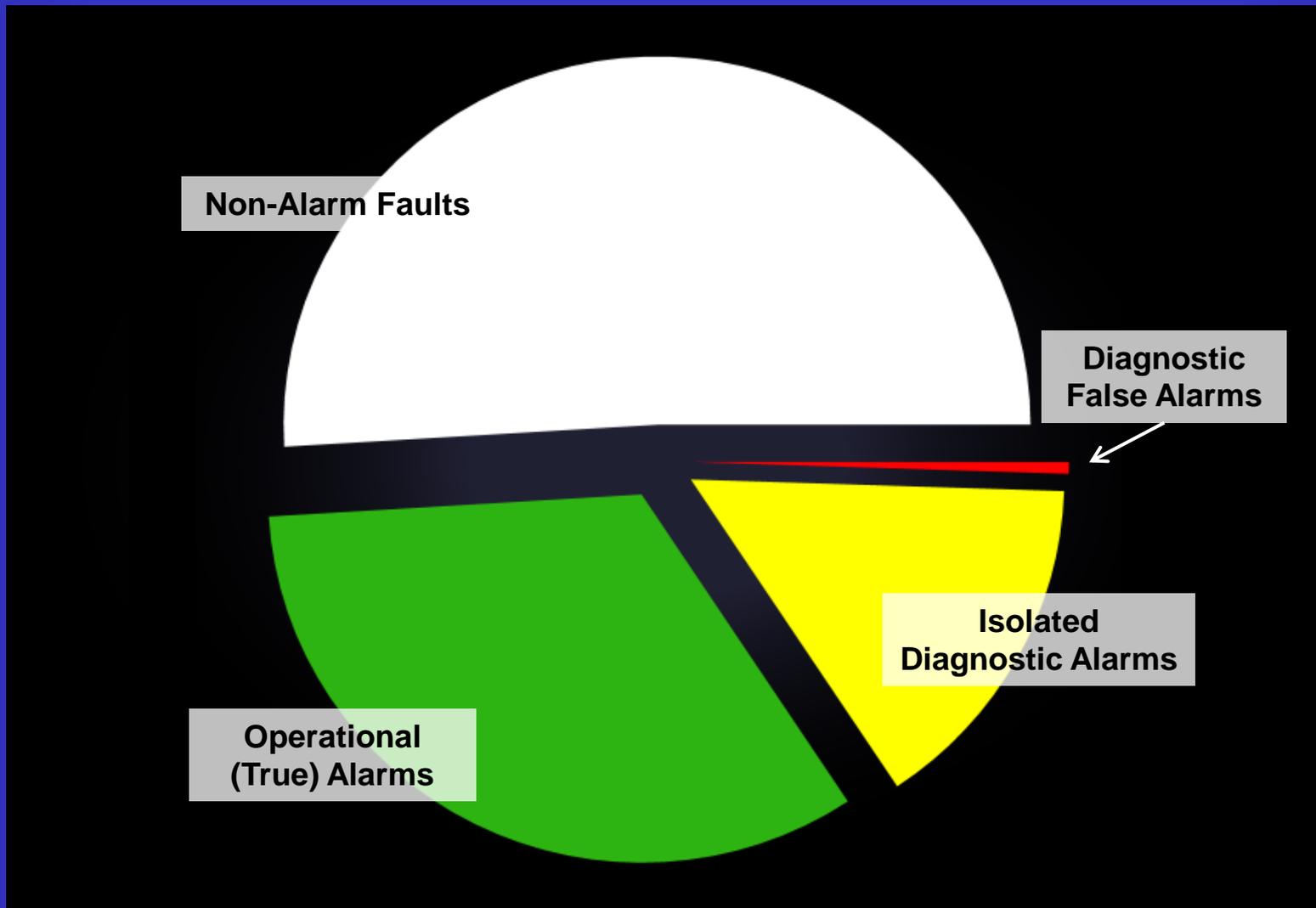
Fault Detection in STAGE



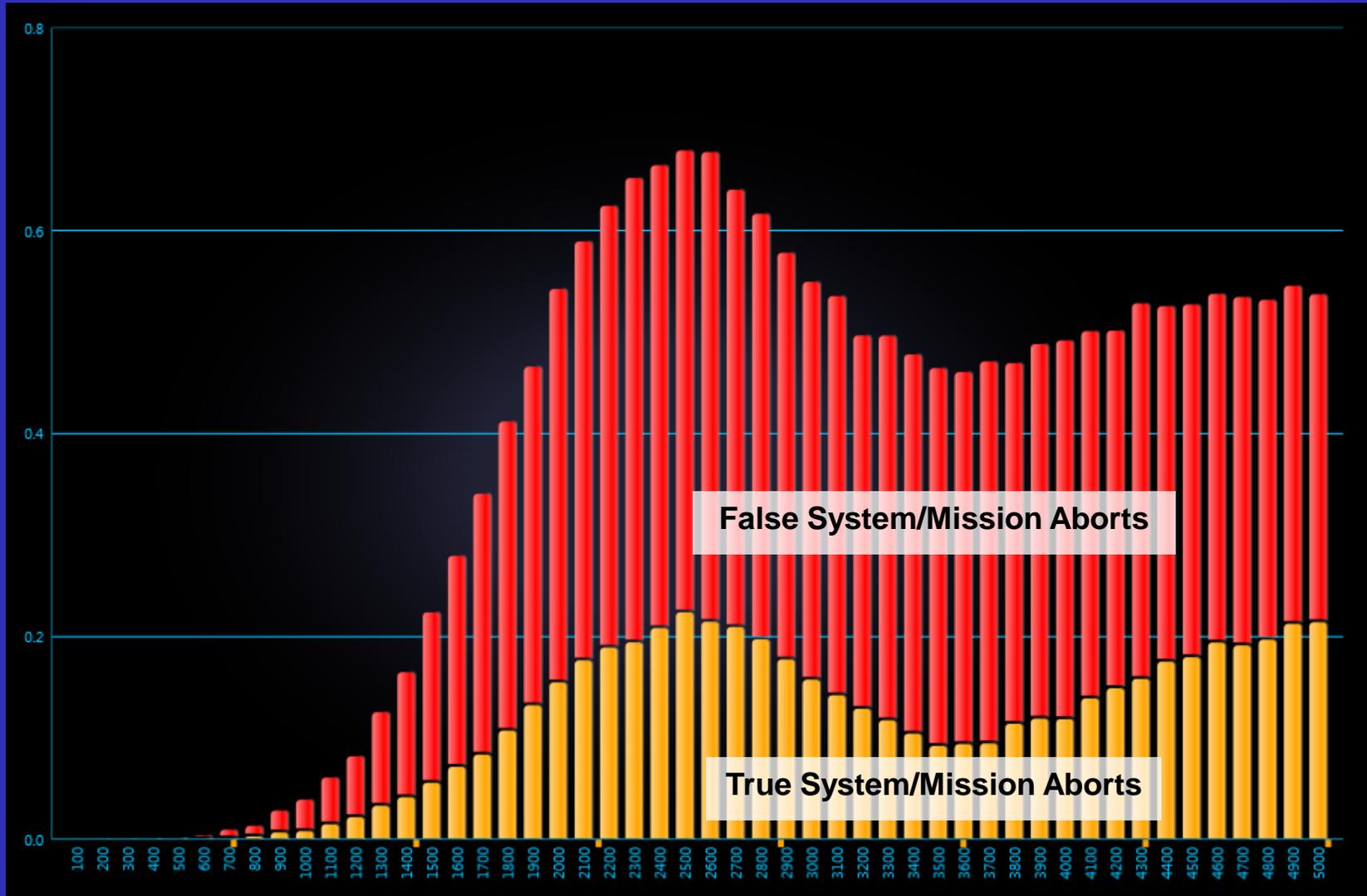
Fault Isolation in STAGE



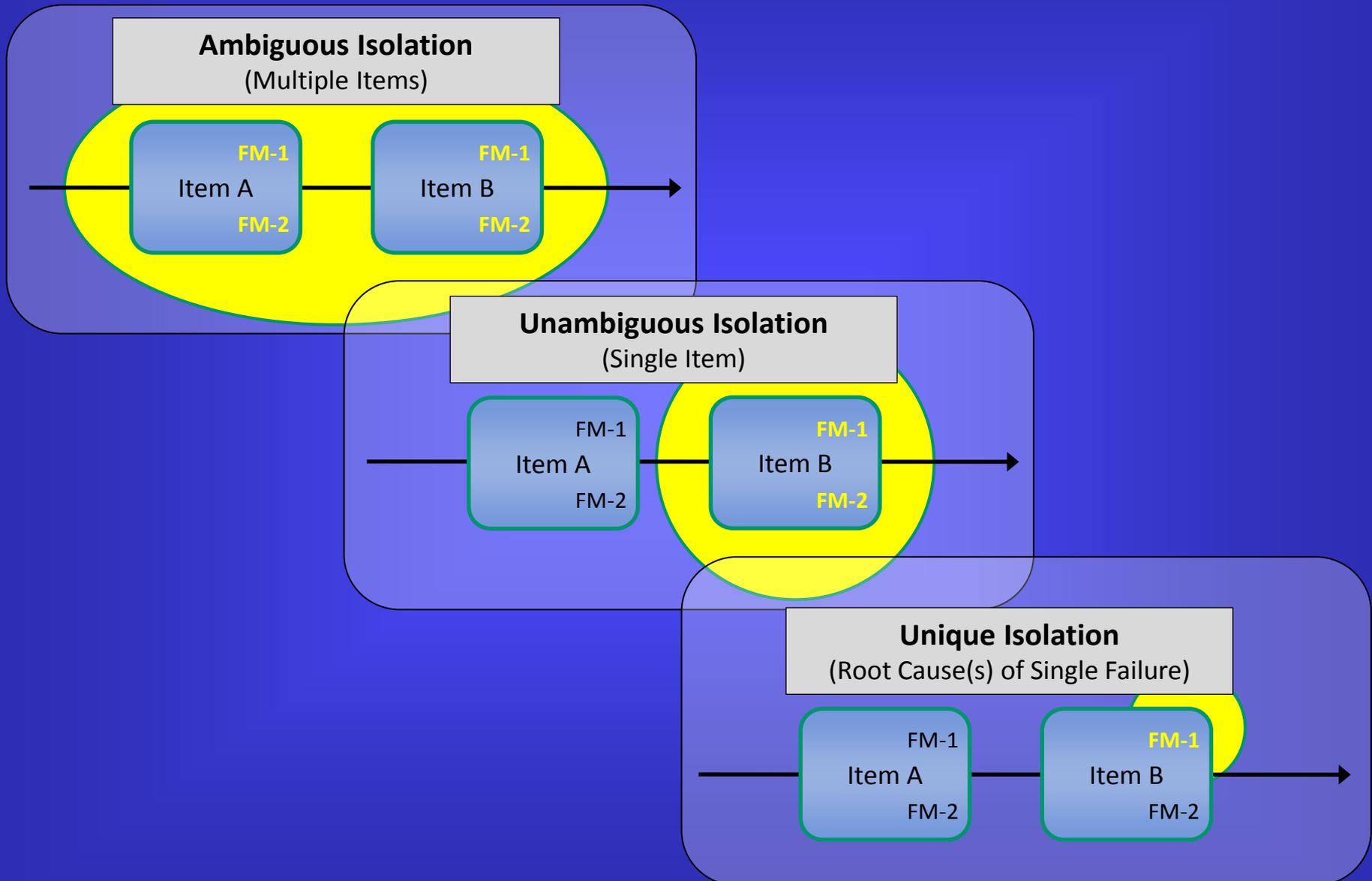
False Alarms in STAGE



System/Mission Aborts in STAGE



Unambiguous vs. Unique Isolation

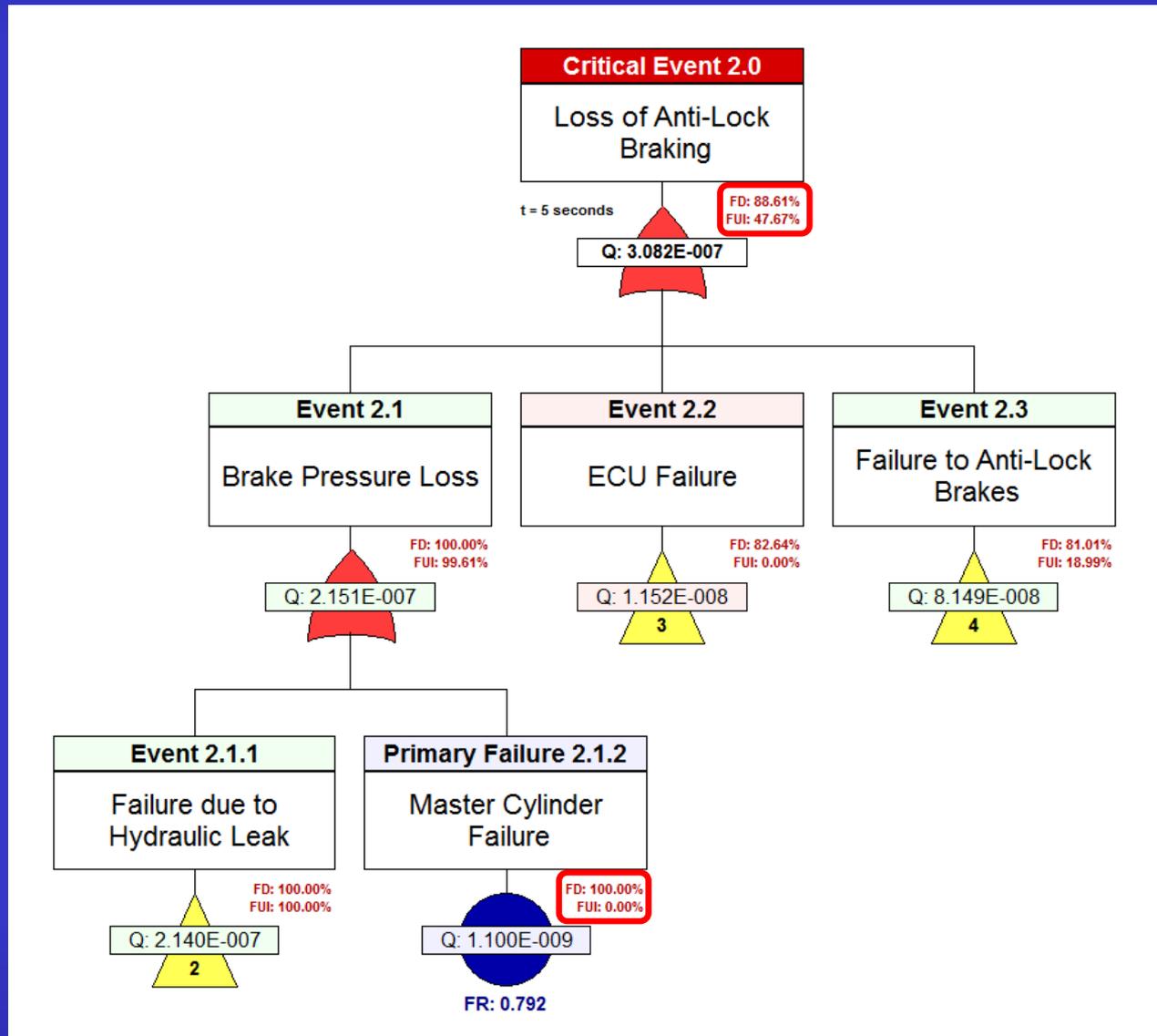


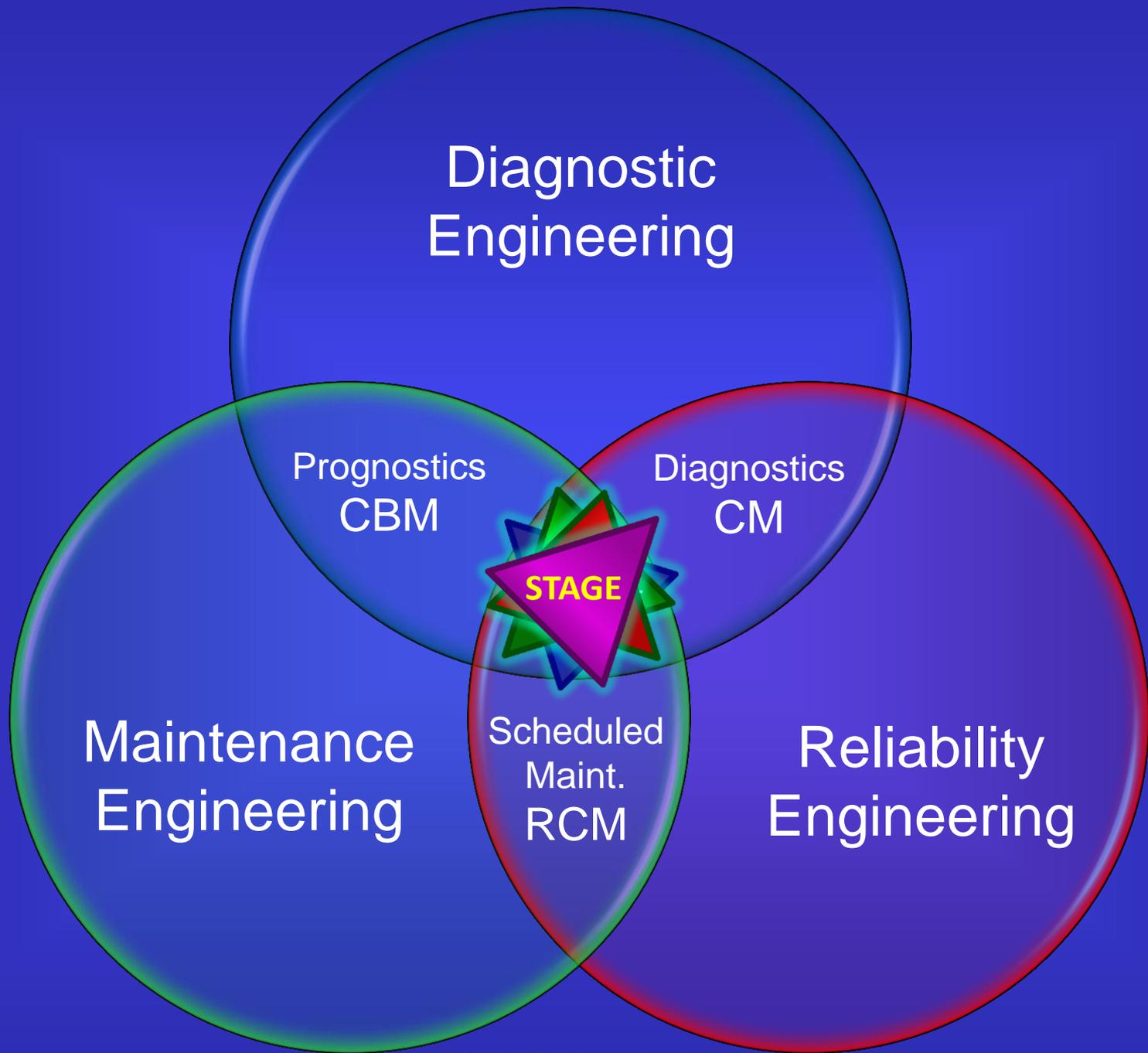
FMECA Plus: Critical Failure Diagnosis Chart

Failure	Item	Failure Rate	Severity Class	Relative Criticality	Diagnostic Coverage				
					Failure Detected	Fault Isolation			
						Uniquely Isolated	Number of Root FMs in Fault Groups	Fault Groups	Fault Group Sizes (Number of Items)
Hydraulic Leak	FS Line	38.026486	Loss of Life	38.0265	Yes	Yes	1	Fault Group # 88	1
Hydraulic Leak	FR Line	38.026486	Loss of Life	38.0265	Yes	Yes	1	Fault Group # 89	1
Forward Pump Failure	Front Pump	19.013243	Loss of Life	19.0132	No	N/A	N/A	N/A	N/A
Rear Pump Failure	Rear Pump	19.012853	Loss of Life	19.0129	No	N/A	N/A	N/A	N/A
L Brake Light Bulb Failure	L Brake Bulb	87.751628	Degraded Performance	17.5503	Yes	Yes	1	Fault Group # 82	1
R Brake Light Bulb Failure	R Brake Bulb	87.751628	Degraded Performance	17.5503	Yes	Yes	1	Fault Group # 84	1
W Brake Light Bulb Failure	RW Brake Bulb	87.751628	Degraded Performance	17.5503	Yes	Yes	1	Fault Group # 85	1
Battery dead	BATTERY	41.639002	Loss of Operation	16.6556	Yes	No	2	Fault Group # 0	1
Solenoid Control Relay Coil Open	Solenoid Relay	11.573041	Loss of Life	11.5730	No	N/A	N/A	N/A	N/A
Battery Fuse Blown	Fuse	11.407946	Loss of Life	11.4079	Yes	Yes	1	Fault Group # 1	1
Pump Relay Cotact Stuck Open	Pump Relay	11.129475	Loss of Life	11.1295	Yes	Yes	1	Fault Group # 23	1
Brake Light Switch Stuck Open	Brake Light SW	9.919749	Loss of Life	9.9197	Yes	No	2	Fault Group # 83	1
Pad1 Wear Beyond Limit	LR Disc Assy:PADS	9.393689	Loss of Life	9.3937	Yes	No	4	Fault Group # 105	1
Pad1 Wear Beyond Limit	LF Disc Assy:PADS	9.393689	Loss of Life	9.3937	Yes	No	4	Fault Group # 102	1
Pad1 Wear Beyond Limit	RR Disc Assy:PADS	9.393689	Loss of Life	9.3937	Yes	No	4	Fault Group # 104	1
Pad1 Wear Beyond Limit	RF Disc Assy:PADS	9.393689	Loss of Life	9.3937	Yes	No	4	Fault Group # 103	1
Tread Worn	LR Tire	45.000000	Degraded Performance	9.0000	No	N/A	N/A	N/A	N/A
Worn Tread	RF Tire	45.000000	Degraded Performance	9.0000	No	N/A	N/A	N/A	N/A
Worn Tread	LF Tire	45.000000	Degraded Performance	9.0000	No	N/A	N/A	N/A	N/A
Worn Tread	RR Tire	45.000000	Degraded Performance	9.0000	No	N/A	N/A	N/A	N/A
Pedal Linkage Failure	Brake Pedal	8.577227	Loss of Life	8.5772	Yes	Yes	1	Fault Group # 3	1
Ignition Switch Stuck Open	Ignition Switch	8.415525	Loss of Life	8.4155	Yes	Yes	1	Fault Group # 2	1
Solenoid Control Relay Ccontact stuck ATCM	Solenoid Relay	7.661896	Loss of Life	7.6619	Yes	Yes	1	Fault Group # 81	1
Solenoid Control Relay Ccontact stuck GND	Solenoid Relay	7.661896	Loss of Life	7.6619	Yes	Yes	1	Fault Group # 80	1
Hydraulic Leak	RS Line	38.027272	Degraded Performance	7.6055	Yes	Yes	1	Fault Group # 86	1
Hydraulic Leak	RR Line	38.027272	Degraded Performance	7.6055	Yes	Yes	1	Fault Group # 87	1

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.

eXpress FTA Module: Fault Tree with FD/FUI





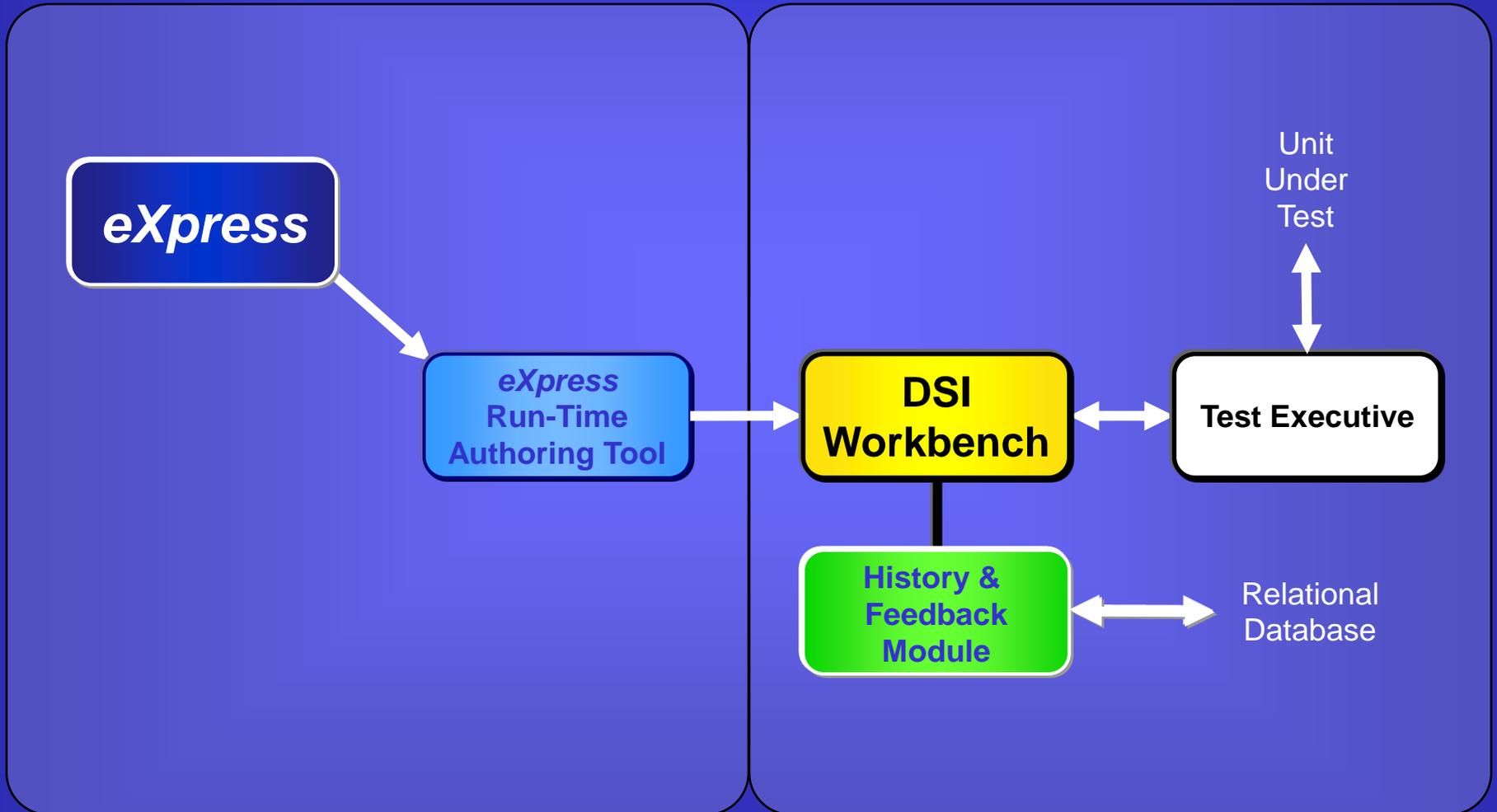
ISDD and the Run-Time Environment

Development

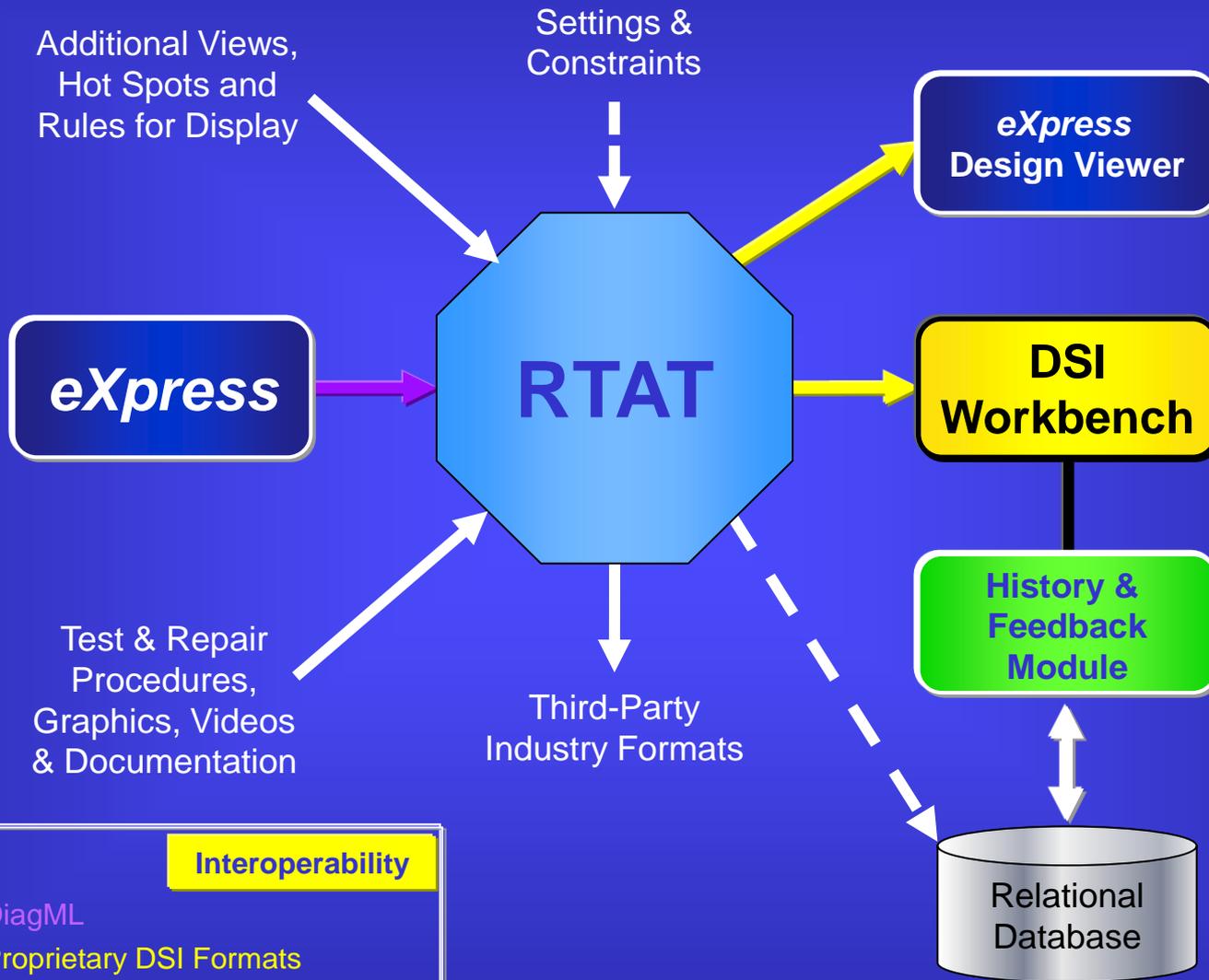
(Engineering, Logistics, Publications, etc.)

Run-Time

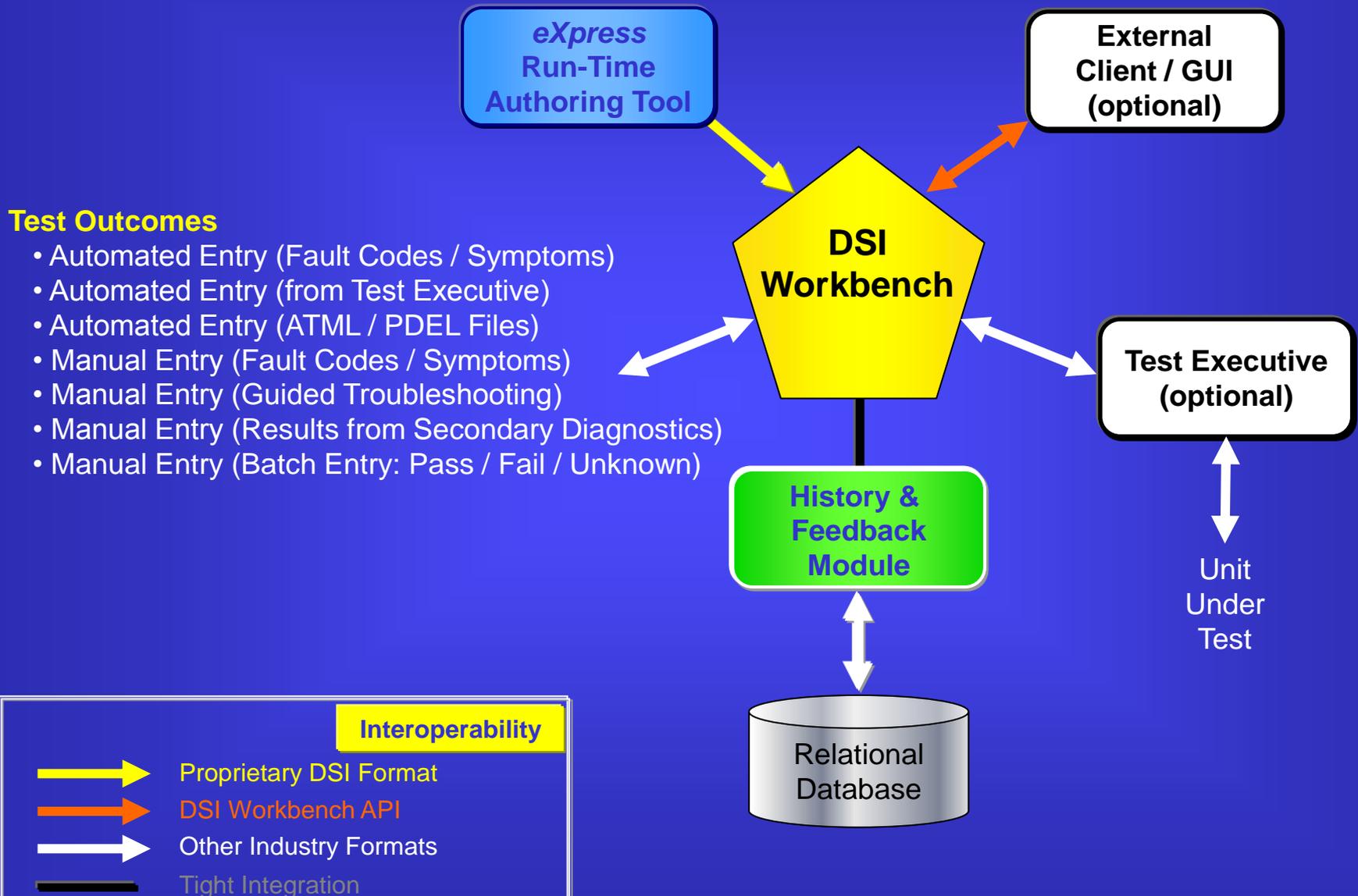
(Production & Maintenance)



The *eXpress* Run-Time Authoring Tool



DSI Workbench



DSI Workbench – Grouping Suspects from Multiple Symptoms / Fault Codes

The screenshot displays the DSI Workbench software interface, which is used for diagnosing complex systems. The interface is divided into several panels:

- Guided Troubleshooting Panel (Top Left):** Shows the current fault isolation point: "Isolated Entry Point: MRL Actuator Fail". It includes buttons for "Restart", "Save and Restart", "Pass", "Fail", "Back", and "Repair". A status message indicates "Isolated to 1 Fault Groups" and "Replace 2 Items".
- Primary Suspects Panel (Bottom Left):** A table listing suspected components and their failure probabilities.

Suspect Item	Suspect Failure	Failure Probability
Main Rotor (AA15):AA15A14		100.0000%
Main Rotor (AA15):AA14A03		<0.000001
Main Rotor (AA15):AA14A03:MAIN ROTOR ACTUA...		
	3.3V REGULATOR OPEN CIRCUIT	
Main Rotor (AA15):AA14A03:MAIN ROTOR ACTUA...		
	GEAR BOX JAMMED	
	SHORTED INPUT FILTER CAPACITOR	
- Rotary Aircraft Demo System View (Middle Left):** A high-level block diagram of the aircraft system, showing various subsystems like Avionics, Electrical, and Vehicle Actuator Installation.
- Rotary Aircraft Avionics - Electrical View (Middle Right):** A detailed block diagram of the avionics and electrical systems, including sections for Avionics Elements, Power Distribution, and Engine Monitoring.
- Main Rotor View (Bottom Middle):** A detailed mechanical diagram of the main rotor assembly, showing components like the shaft, swashplate, and actuators. Key components are highlighted in red: "Rotating Swashplate", "Swashplate bearing", and "Control Swashplate".
- AA14A03 View (Bottom Right):** A detailed block diagram of the AA14A03 actuator system, showing the main rotor actuator power supply, flight bus, and various controllers.
- Vehicle Actuator Installation View (Far Right):** A 3D CAD model of the vehicle actuator assembly.

The bottom of the interface shows a "Diagnostic Status View" with a progress indicator.

DSI Workbench – History & Feedback Module

DSI Workbench Preview [Braking System]

File View Reports Tools Database Help

Restart Session Guided Start Monitor Monitor Control Test Results Panel Layout

Guided Troubleshooting

Isolating 3 Failures

End Save and Restart

Pass Fail

Back Repair

Test 1-1
Check BATTERY

Check Battery:



Wear safety glasses. These are the three most common causes of a battery that sulfuric acid on a car. If nothing else, wear safety glasses.



Checking voltage. A battery's condition can remain artificially good for hours or more.

Remediations [Ticket T000001]

Ticket: T000001

UUT Identification: UUT: Braking System version
Version: 1
Serial Number: 01

Session: Location: Test Station 1
User ID: 1
Name: Default User

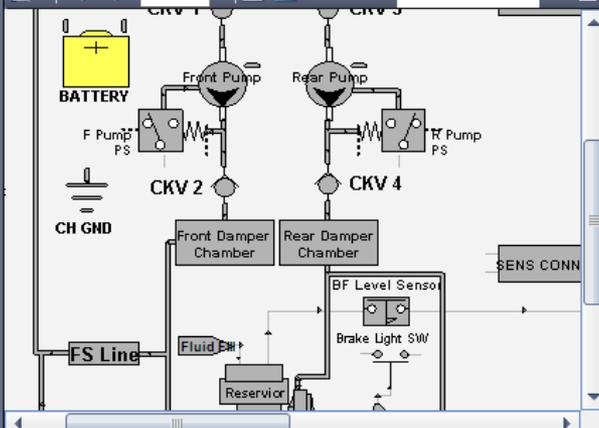
Current Suspects	Remediati...	Probability
BATTERY	3	69.7152 %
Fuse	2	17.4288 %
Ignition Switch	0	12.8560 %

Remediations: This Ticket Only

Remediation Item	Corrective Action	Comment	Date
BATTERY	Clean and Rec...		8/21/2013 9:33...
Fuse	Replace Fuse		8/21/2013 9:33...

OK Cancel

[Braking System]



[Fuse Box]



Primary Suspects

Suspect Item	Failure Probability
BATTERY	0.697152
Battery dead	
Battery Partially Shorted Internally	
Fuse	0.174288
Battery Fuse Blown	
Ignition Switch	0.128560
Ignition Switch Stuck Open	

Primary Suspects Suspected Connections

Resolution History

Date Range: Last 90 Days Start Date: 5/23/2013 End Date:

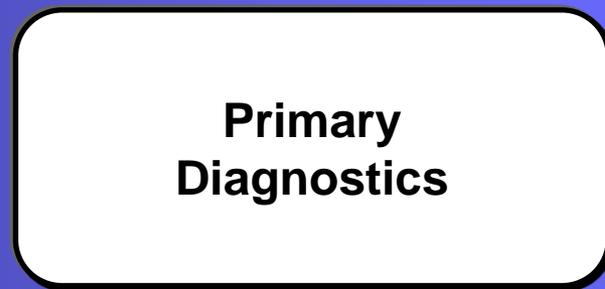
Resolution	Resolution Date
Replaced Components	8/21/2013 9:34:52...
Replace Fuse	8/21/2013 9:33:49...
Repaired Components	8/21/2013 9:35:35...
Clean and Reconnect Battery Cables	8/21/2013 9:33:08...
Reconfigured Unit	8/21/2013 9:35:54...
Clean and Reconnect Battery Cables	8/21/2013 9:33:37...
Upgraded Unit	8/21/2013 9:36:21...
Replace BATTERY	8/21/2013 9:33:43...

Diagnostic Status View

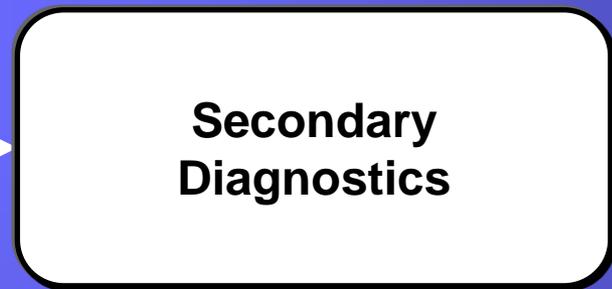
Bridging Multiple Levels of Diagnostics Using the *eXpress* Maintenance Module

Primary Diagnostics

Secondary Diagnostics



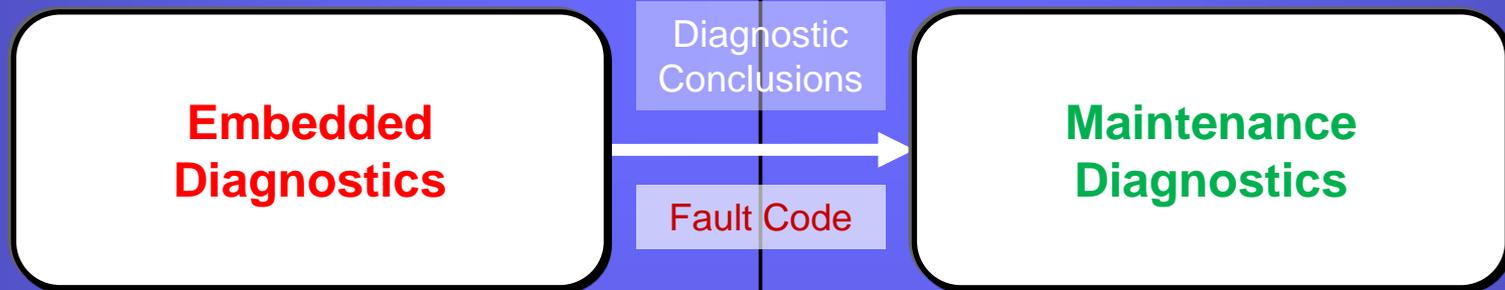
Diagnostic Conclusions



Bridging Multiple Levels of Diagnostics Using the *eXpress* Maintenance Module

On Board the System

Maintenance Facility



Bridging Multiple Levels of Diagnostics Using the *eXpress* Maintenance Module

Diagnostics In the Field

Maintenance Depot

**O-Level
(Operational)
Diagnostics**

Diagnostic
Conclusions

Fault Code

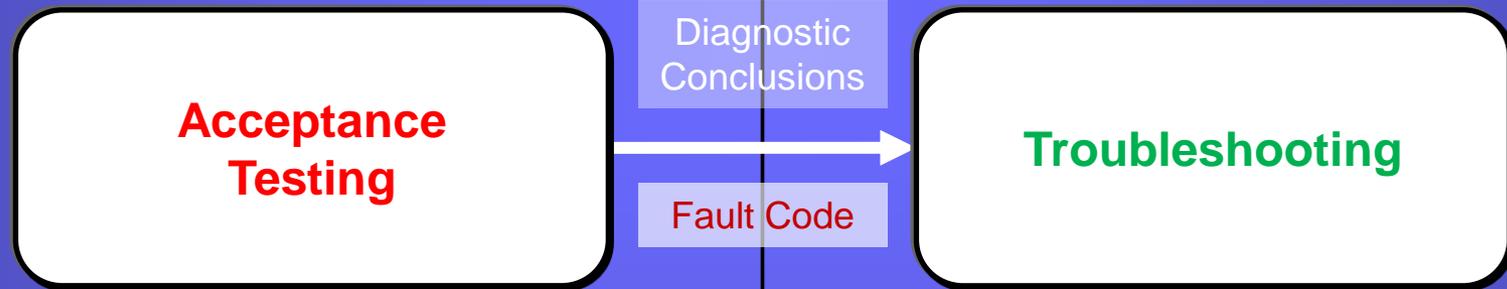
**I-Level
(Intermediate)
Diagnostics**



Bridging Multiple Levels of Diagnostics Using the *eXpress* Maintenance Module

Production Floor

Troubleshooting Group



Bridging Multiple Levels of Diagnostics Using the *eXpress* Maintenance Module

Automatic Test Equipment

