Qualtech Systems, Inc. (QSI)

QSI
teamqsi.com

The Shortest Path to Uptime

Core capabilities

- Guided Troubleshooting Solution
- Deliver System Availability through Comprehensive Integrated Diagnostics and Prognostics
- Embedded Diagnostics
- Design for Service

Customers using QSI technology

- NASA and DoD
- Aerospace
- Medical Equipment
- Semiconductor Equipment
- Automotive

Credentials

- Multiple patents on core technology
- Multiple NASA Space Act Awards
- Technology Innovation Award
- Aviation Week Award
- Harry T. Jensen Award from AHS

Key Resources and Partnerships

- Renowned research team with long history of award-winning publications
- Partnerships with premier institutes such as Univ. of Maryland, Vanderbilt, UConn
- Longstanding partnership with primes

Commercialized Products

TEAMS-Designer®, TEAMS-RDS®

TEAMATE®, TEAMS-RT®, PackNGo®

Commercialization Success

- Fifty percent of annual revenue from commercial sales and services
- Nearly 60% Commercialization Index with significant product sales in the past five years

Smart Manufacturing Centers – a Fault Management challenge

- **Increased automation of manufacturing processes is a Fault Management challenge**
  - Complex and diverse equipment from different manufacturers working together co-operatively
  - The manufacturing process, the associated equipment, their controls, timing and synchronization lead to significant challenges in timely failure detection, accurate failure root-cause(s) identification and mitigation
    - ✓E.g., Product failure origin and its detection point locations can be in entirely different equipment
  - Lack of across-the-board process and equipment maintenance expertise, knowledge, training

QSI and WR-ALC's Solution Approach

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- **Key initial step towards meeting fault management challenge:**
  - Identification of process-level failure modes and their effects
  - Identification of equipment-level failure modes, cross-subsystem dependencies and their effects
  - Identify cross-process and cross-equipment dependencies
- **Solution Approach:**
  - QSI and Warner-Robins Air Logistics Complex adopting a model-based methodology for automated development of Process-level FMECA, equipment-level FMECAs and their integration
  - Failure-cause effect dependency models such as developed in TEAMS are easily updateable, configurable and provide for consistent information capture across different interacting machinery
  - Reasoning algorithms using those models allow Health Assessment and Guided Troubleshooting across different equipment with drill-down capability
  - https://youtu.be/D_eTd3QR384

❖ **TEAMS® fault management adopted for MAKINO T4 equipment and the Advanced Metal Finishing Facility (AMFF) at Warner-Robins**

The Modeling Process in TEAMS®

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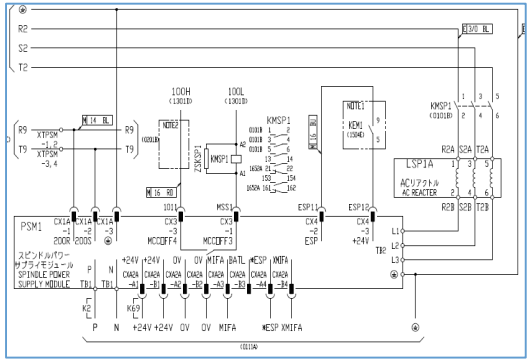
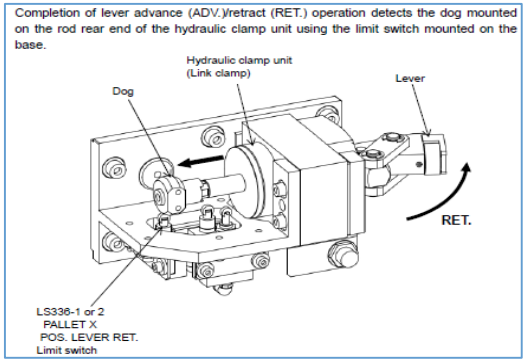


924225 APC Pallet Load/Unload Operation Condition Error
- Type: Alarm / Inhibit Cycle Start
- Cause
  Cannot perform pallet change because WSS1 tilt prevent pin out confirm signal On.
- Recovery
  Check status of WSS1 tilt prevent pin.
  If the signal does not go On even though the prevent pin is out, it indicates a confirm limit switch defective part, improper adjustment of the limit switch or a broken cable.

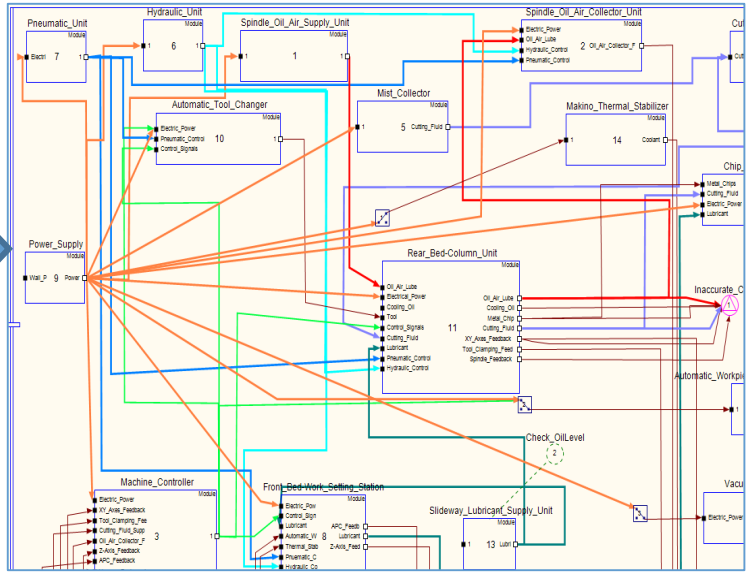
924226 APC Pallet Load/Unload Operation Condition Error
- Type: Alarm / Inhibit Cycle Start
- Cause
  Cannot perform pallet change because WSS1 hydraulic unit motor circuit breaker is Off.

Completion of lever advance (ADV.)/retract (RET.) operation detects the dog mounted on the rod rear end of the hydraulic clamp unit using the limit switch mounted on the base.



- Capture Modules, Interconnections, Hierarchy in a Directed Graph
- Add Failure Modes and (affected) functions as appropriate
- Add Tests and Effects with (monitored) functions as appropriate
- **TEAMS® identifies upstream failure modes (detections) for each test/effect and vice-versa**

TEAMS® Failure-Cause Effect Dependency Model



Process-level and Equipment-level failures using TEAMS®

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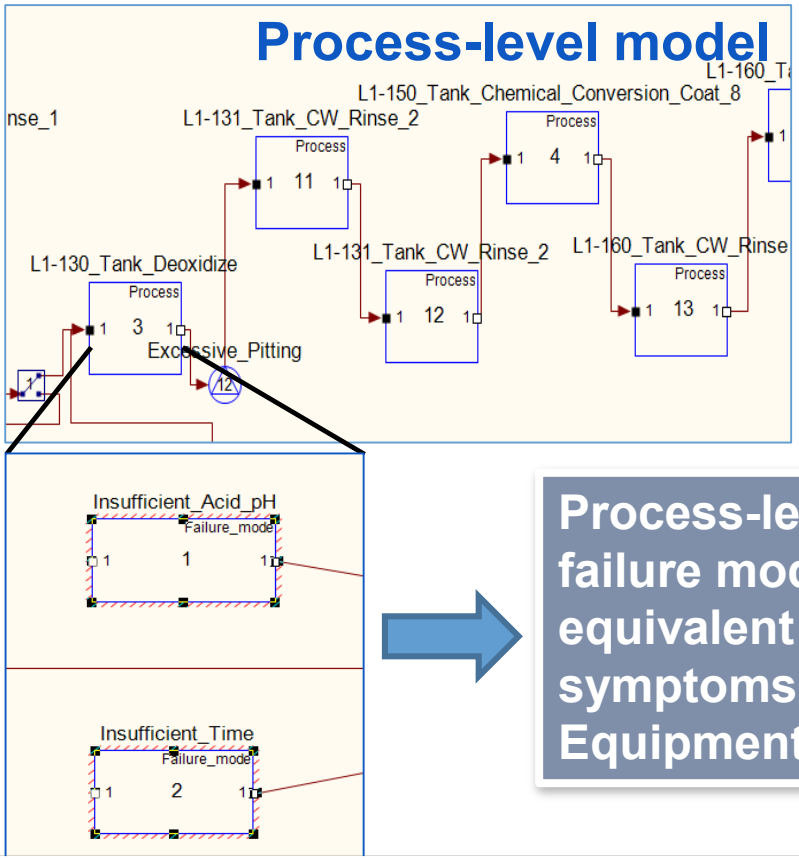

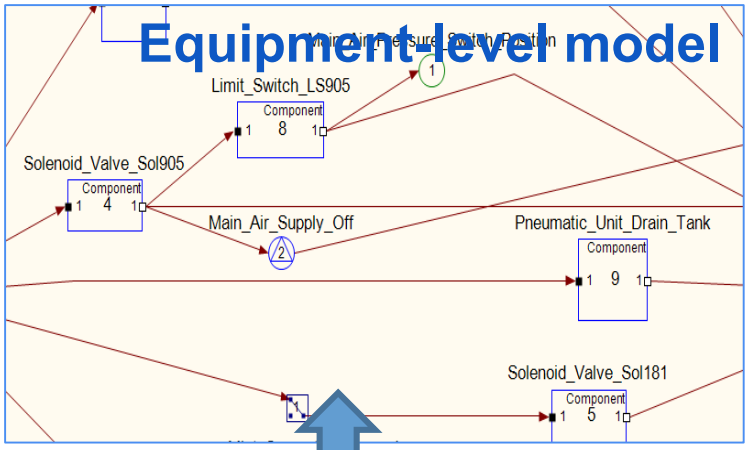

Process-level failure modes are equivalent to failure symptoms at the Equipment-level

❖ **Bringing together Process-level and Equipment-level failures using TEAMS® hierarchical causal models**

Failure Propagation and Dependency Reports

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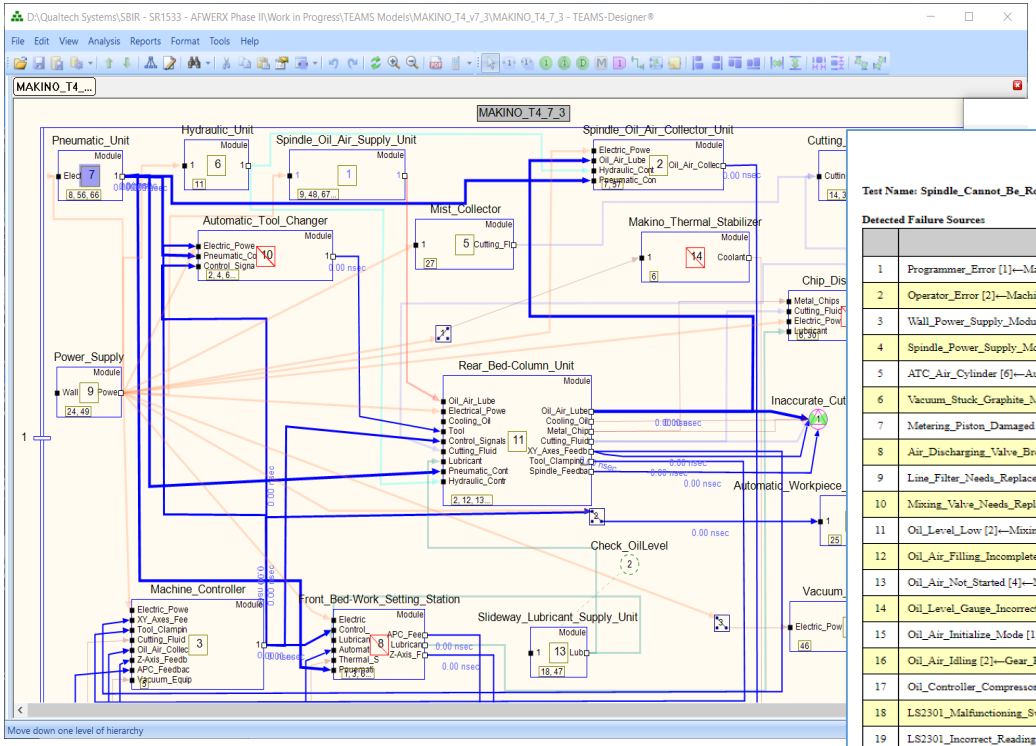

QSI team is using some of the Dependency reports for model validation

TEST DEPENDENCY REPORT for MAKINO_T4_7_3

2019-09-06 21:14:20Z

Test Name: Spindle_Cannot_Be_Rotated[1]←Effect_Container [10]←Rear_Bed-Column_Unit [11]

Detected Failure Sources

	Name	MTTF
1	Programmer_Error [1]←Machine_Controller [3]	1e+06
2	Operator_Error [2]←Machine_Controller [3]	1e+06
3	Wall_Power_Supply_Module [1]←Power_Supply [9]	1e+06
4	Spindle_Power_Supply_Module [3]←Power_Supply [9]	1e+06
5	ATC_Air_Cylinder [6]←Automatic_Tool_Changer [10]	1e+06
6	Vacuum_Stuck_Graphite_Mode [1]←Vacuum_Equipment [16]	1e+06
7	Metering_Piston_Damaged [1]←Metering_Piston [1]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
8	Air_Discharging_Valve_Broken [1]←Air_Discharging_Valve [2]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
9	Line_Filter_Needs_Replacement [1]←Oil_Line_Filter [3]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
10	Mixing_Valve_Needs_Replacement [1]←Mixing_Valve [4]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
11	Oil_Level_Low [2]←Mixing_Valve [4]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
12	Oil_Air_Filling_Incomplete [3]←Mixing_Valve [4]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
13	Oil_Air_Not_Started [4]←Mixing_Valve [4]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
14	Oil_Level_Gauge_Incorrect_Reading [1]←Oil_Level_Gauge [5]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
15	Oil_Air_Initialize_Mode [1]←Gear_Pump [6]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
16	Oil_Air_Idling [2]←Gear_Pump [6]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
17	Oil_Controller_Compressor_Problem [3]←Gear_Pump [6]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
18	LS2301_Malfunctioning_Switch [1]←Limit_Switch_LS2301 [7]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
19	LS2301_Incorrect_Reading [2]←Limit_Switch_LS2301 [7]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
20	LS2308_Malfunctioning_Switch [1]←Limit_Switch_LS2308 [8]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
21	LS2308_Incorrect_Reading [2]←Limit_Switch_LS2308 [8]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
22	LS2307_Malfunctioning_Switch [1]←Limit_Switch_LS2307 [9]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
23	LS2307_Incorrect_Reading [2]←Limit_Switch_LS2307 [9]←Spindle_Oil_Air_Supply_Unit [1]	1e+06
24	XY-Axes_Feedback_Control_Module_Error [1]←XY-Axes_Feedback_Control_Module [3]←Machine_Controller [3]	1e+06
25	Tool_Clamping_Feedback_Control_Module_Error [1]←Tool_Clamping_Feedback_Control_Module [4]←Machine_Controller [3]	1e+06
26	Cutting_Fluid_Supply_Feedback_Control_Module_Error [1]←Cutting_Fluid_Supply_Feedback_Control_Module [5]←Machine_Controller [3]	1e+06

FMECA, Testability Analysis, Additional Test Points Recommendation

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IDENTIFICATION NUMBER	ITEM/FUNCTIONAL IDENTIFICATION (NOMENCLATURE)	FUNCTION	FAILURE MODES AND CAUSES	MISSION PHASE/ OPERATIONAL MODE	FAILURE EFFECTS			FAILURE DETECTION METHOD
					LOCAL EFFECTS	NEXT HIGHER LEVEL	END EFFECTS	
6321dd13de026186448fc83d158a5c6d	Slideway_Lubricant_Supply_Unit	Slideway_Lubrication	Slideway_Air_Discharging_Plug	All_Phases	Z-Axis_No_Movement, X-Axis Movement_Im			Limit_Switch_Position
7953f2836bf9552b696944cf25564c95	Makino_Thermal_Stabilizer	Makino_Thermal_Stabilization	Coolant_Reservoir_Tank	All_Phases				
ea46a2c8e1a864bab032d7452bd144be	Makino_Thermal_Stabilizer	Makino_Thermal_Stabilization	Coolant_Supply_Pump	All_Phases				
1596d95d91532012d857a86b8f2a250c	Automatic_Workpiece_Measuring_Unit_Marposs	Automatic_Workpiece_Measuring	AWMM_Stylus	All_Phases				

D:\Qualtech Systems\SBIR - SR1533 - AFWERX Phase II\Work in Progress\TEAMS Models\MAKINO_T4_v7_3\MAKINO_T4_7_3 - TEAMS-Designer®

File Edit View Analysis Reports Format Tools Help

TESTABILITY REPORT FOR MAKINO_T4_7_3

2019-09-06 21:05:31Z

TEST OPTIONS

Test Algorithm: NEAR OPTIMAL (Breadth=1, Depth=1)

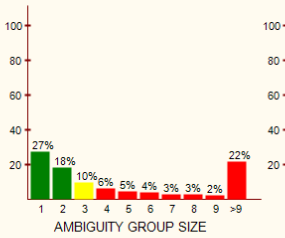
TESTABILITY FIGURES OF MERIT

Percentage Fault Detection	=	99.14 %
Percentage Fault Isolation	=	27.19 %
Percentage Fault Isolation (MIL STD)	=	27.19 %
Percentage Retest OK's	=	55.18 %
Avg. Ambiguity Group Size	=	8.98
Number of No-Fault Found (per 1000 Systems per Year)	=	43.31
Mean Weighted Cost To Isolate and Repair	=	0.00
Dollar Cost to Isolate and Repair	=	0.00
Time to Isolate and Repair	=	0.00
Mean Cost To Detect	=	0.00
Mean Time To Detect	=	0.00

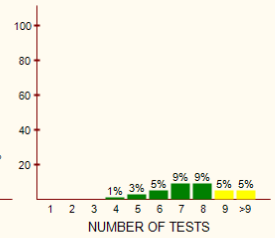
Add Tests at the following locations

	TEST	FUNCTIONS DETECTED
1	Spindle_Oil_Air_Supply_Unit [1]:O/P_1	[-] Spindle_Oil_Air_Lubrication
2	Chip_Disposal_Unit [4]:O/P_3 (Waste_Oil)	[-] Main_Air_Supply_Off; Pneumatic_Unit_Running; Power_Supply; Servo_Power_Supply; Spindle_Power_Supply
3	Mist_Collector [5]:O/P_1 (Cutting_Fluid)	[-] ATC_Shutter_Operation; Tool_Change_Operation
4	Automatic_Pallet_Changer [6]:O/P_1	[-] Spindle_Movement_Y-Axis; Y-Axis_Movement_Impeded; Y-Axis_Movement_Jarred; Y-Axis_No_Movement; Y-Axis_Power_Supply

Histogram of Ambiguity Size



Histogram of Test Usage



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Test point recommendations focus on reducing ambiguities and improving fault isolation

Guided Troubleshooting

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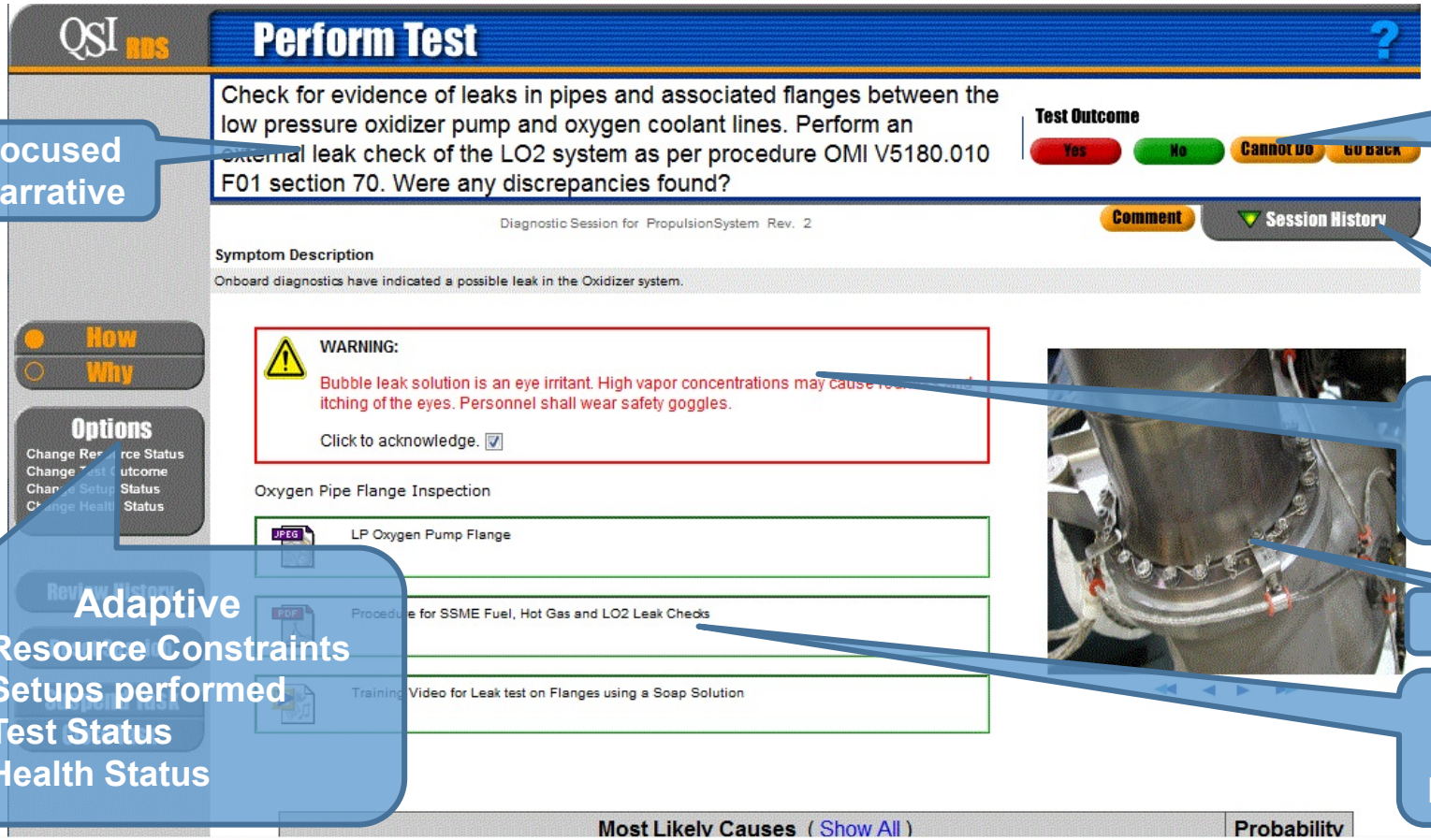

Focused Narrative

Dynamic Reasoner Driven

Logs

Cautions, Advisories, Warning

Multimedia

Links to Manuals, Doc servers

Adaptive

- Resource Constraints
- Setups performed
- Test Status
- Health Status

❖ **TEAMS-RDS® generates the troubleshooting logic and assembles the instruction set based on user needs and capabilities**

Follow-up

- **Tomorrow 10:45am in Apache III - Tech Demo 4 - Testability Engineering And Maintenance System (TEAMS) Toolset**
- **Thursday 3:15 – 4:45pm Paper Session 12B: Anomaly Detection II; Pueblo I & II**
  - An Integrated Model-based Approach for FMECA Development – for Smart Manufacturing Applications